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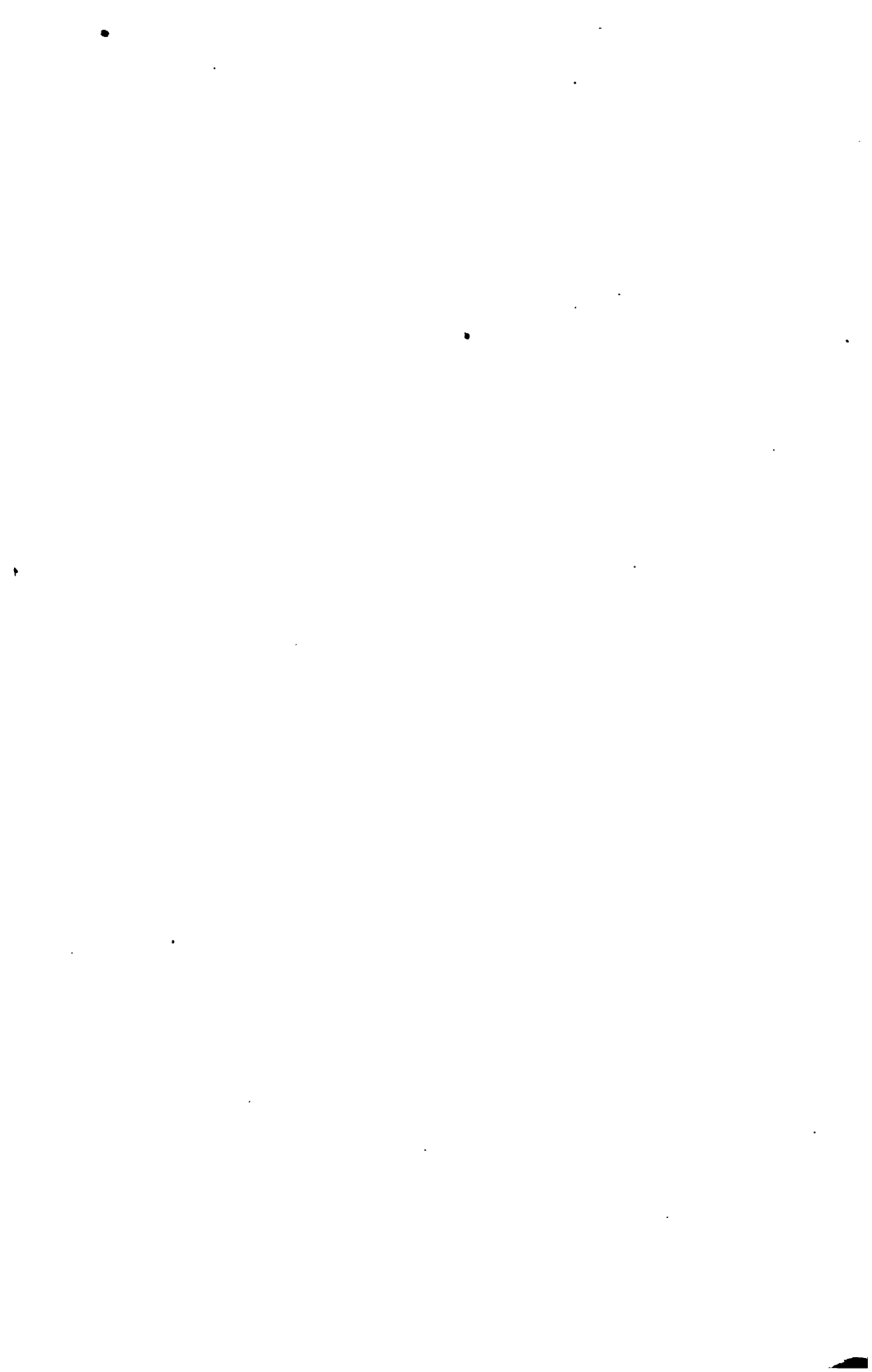
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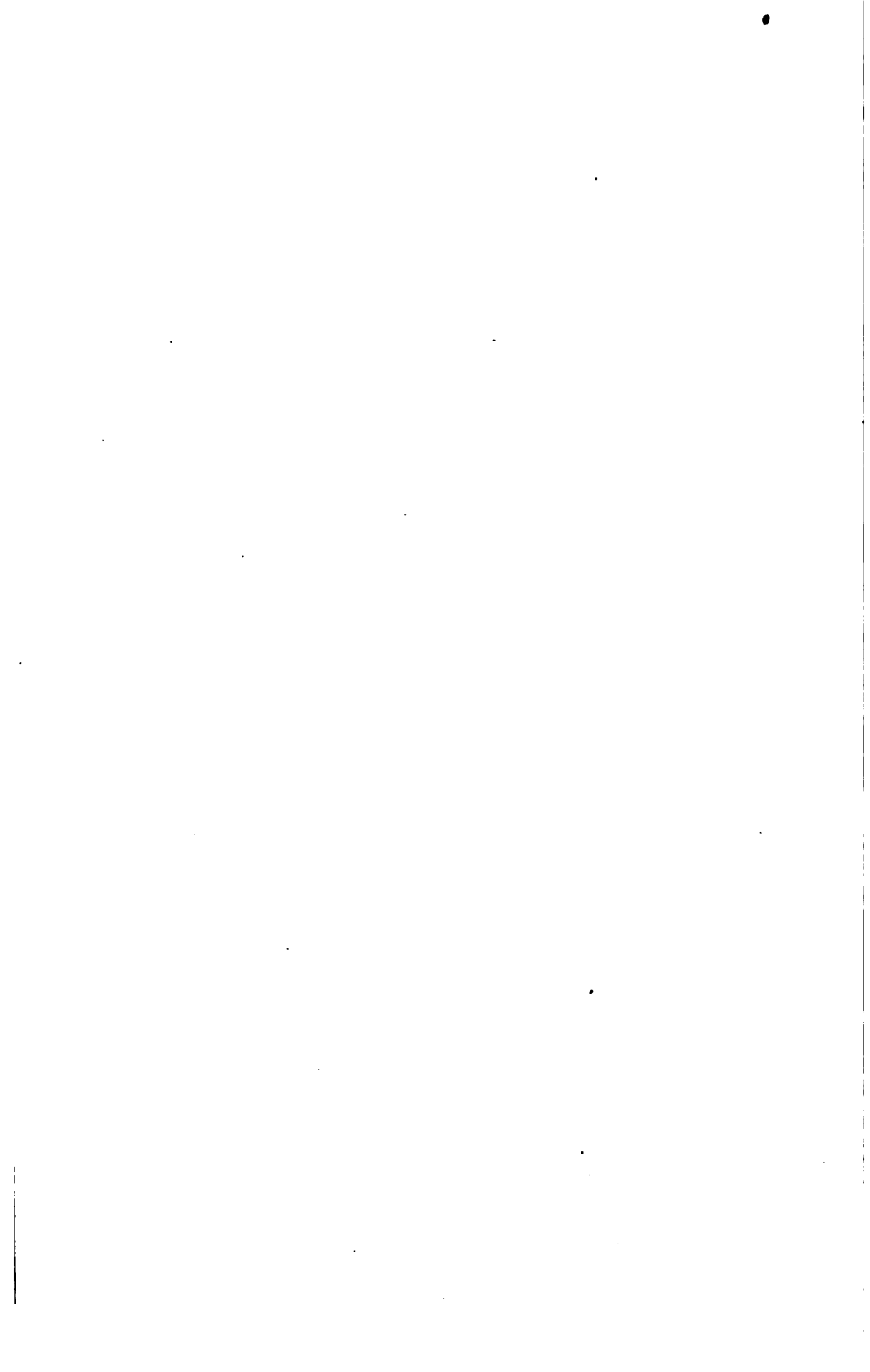
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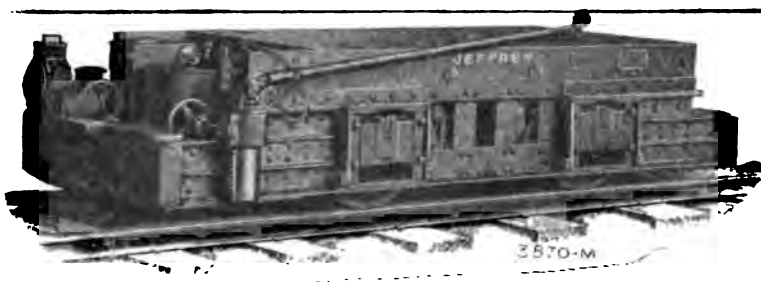


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BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

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1910

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ERRATA.

Corrections to *Bulletin* No. 36, December, 1909

P. 1059, Seattle, Wash., Committee, for F. A. Thomson, read C. M. Lewis.

P. 1085, bottom row of portrait group, for Mrs. Frank A. Hill, read Mrs. Chester F. Lee.

SECTION I.—INSTITUTE ANNOUNCEMENTS.

This section contains announcements of general interest to the members of the Institute, but not always of sufficient permanent value to warrant republication in the volumes of the *Transactions*.

SECTION II.—TECHNICAL PAPERS AND DISCUSSIONS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

A detailed list of the papers contained in this section is given in the Table of Contents. They have been so printed and arranged (blank pages being left when necessary) that they can be separately removed for classified filing, or other independent use.

A small stock of separate pamphlets, duplicating the technical papers given in Section II. of this Bulletin, is reserved for those who desire extra copies of any single paper.

Comments or criticisms upon all papers given in this section, whether private corrections of typographical or other errors or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.

All communications concerning the contents of this Bulletin should be addressed to Dr. Joseph Struthers, Assistant Secretary and Editor, 29 W. 39th St., New York, N. Y. (Telephone number 4600 Bryant).

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For the year ending February, 1910.

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* SECRETARY'S NOTE.—The Council is the professional body, having charge of the election of members, the holding of meetings (except business meetings), and the publication of papers, proceedings, etc. The Board of Directors is the body legally responsible for the business management of the Corporation, and is therefore, for convenience, composed of members residing in New York.

INSTITUTE ANNOUNCEMENTS.

Proposed Increase of Annual Dues.

At the Annual Meeting of the Institute, February, 1908, the following amendments to the Constitution were proposed for action at a future business meeting (see *Trans.*, XXXIX, xxvii):

To Art. II. After the first sentence of this Article, add the following sentence:

“These classes may be subdivided by the Council, according to profession, length of membership, nationality, or other conditions not inconsistent with the provisions of this article.”

To Art. III. In the first line, substitute “fifteen” for “ten” dollars.

At the Annual Meeting of February, 1909, action upon these amendments was postponed to the next business meeting (see *Bulletin* No. 27, March, 1909, p. xiv).

Of these two amendments, the first has been withdrawn, as unnecessary—the subdivision thereby authorized being already practicable without such amendment.

The second amendment will be acted upon at the next Annual Meeting, February 15, 1910, and the Secretary has been instructed to call the attention of members to the subject in such a way as to secure a general vote upon it. A special circular, now being prepared by the Secretary, will shortly be sent to all members.

Year Book of the Institute.

The Year Book of the Institute for 1910 is sent to all members and associates with this issue of the *Bulletin*. In addition to the lists of members enrolled Jan. 1, 1910, and arranged both alphabetically and geographically, this annual contains lists of officers, council, corporation, past officers, meetings, and notices concerning publications; also the constitution and by-laws of the Institute, and blank forms for proposal of mem-

bership and change of address. In order to facilitate the work of the Institute, each member is earnestly requested to give prompt notice of any change of address to the Secretary's office.

International Congress for Mining, Metallurgy, Applied Mechanics, and Practical Geology, Düsseldorf, 1910.

As already announced in *Bulletin No. 32*, August, 1909, the Congress will meet at Düsseldorf during the last week in June, 1910. Extensive preparations are in progress, including visits to technical institutions and industrial establishments, excursions to localities of geologic interest, etc., which will have a direct bearing on the papers and addresses presented at the meeting.

The following information, dated October, 1909, has been received from the Secretary of the Congress:

Membership:

There will be two grades of membership of the Congress, as follows:

1. Members, who are entitled to become patrons of the Congress by payment to the funds of a contribution of not less than 100 marks (£5).

2. Members, who pay a subscription of 20 marks (£1).

The first-named class of members or patrons will be entitled to receive the printed reports of all proceedings of the Congress and of all its sections. Members of the second class, or ordinary members, will receive the reports of that section only in which they enroll themselves. The proceedings of any one of the other sections are obtainable at an additional charge of 5 marks (5s.) in each case.

Meetings and Excursions:

The work of the Congress will be performed:

1. In General Meetings, at which various papers of general interest will be presented.

2. In sectional Meetings, for the purpose of discussing important problems relating to Mining, Metallurgy, Applied Mechanics, and Practical Geology.

3. By making visits to scientific Institutions and industrial undertakings, etc., and by excursions to districts of geological interest.

For the purpose of entertaining ladies accompanying members to the Congress, a Ladies' Committee will be formed, which will endeavor in every way to render the stay of the lady visitors in Düsseldorf as agreeable and enjoyable as possible.

Provisional Program:

Section I: Mining.

1. Shaft-sinking, with special reference to the cement processes, freezing processes, and tubbing of shafts at great depths. The lining of shafts with concrete and reinforced concrete.

2. Methods of working, mine supports, with special reference to hydraulic packing, the use of reinforced concrete, the preservation of timber, and lighting of collieries.
3. Winding and haulage, with special reference to winding ropes, safety-catches and appliances, underground haulage, and haulage from the working faces.
4. Mine drainage.
5. Risks arising from fire-damp, coal-dust, and underground fires, and the methods of combating these.
6. The mechanical preparation of coal and ore, the recovery of bye-products, briquetting, and the utilization of low-grade fuels.
7. Recent practice in mine surveying.
8. Statistics.
9. Sanitation and hygiene.

Section II: Metallurgy.

A. Production of pig iron.

1. Coking.
 - (a) Ovens.
 - (b) Mechanical appliances.
 - (c) Recovery of bye-products.
2. Ore supply.
 - (a) Recent discoveries of ore.
 - (b) Recent development and prospects of the ore briquetting processes.
3. Metallurgy of the blast-furnace process.
 - (a) Influence of foreign substances.
 - (b) Composition of slag.
4. Blast-furnace working.
 - (a) Ore conveyance, storage, and charging.
 - (b) Gas-washing and purification of the waste water.
 - (c) Dry air-blast.
 - (d) Casting machines and mixers.
5. Utilization of waste products.
 - (a) Gases.
 - (b) Dust from blast-furnace gases.
 - (c) Slag (for hydraulic packing, cement, stone, concrete).

B. Production of malleable iron.

1. Advances in the methods of the metallurgical treatment of iron and steel.
 - (a) Air-blast refining processes.
 - (b) Open-hearth refining processes.
 - (c) Processes for the production of electro-steel.
2. Production and treatment of special alloys of steel.

C. Iron and steel manufacture.

1. Improvements in the methods of casting iron and steel.
2. Further treatment of malleable iron.
 - (a) Forging and pressing.
 - (b) Rolling.
 - (c) Fitting.
 - (d) Development of the welding processes.

8. The driving of rolling-mills considered technically and economically (steam, gas, electricity).

D. Testing of iron and other metals.

1. Chemical testing.
2. Mechanical testing.
3. Metallography and microscopy of metals.

E. Economics of the iron industry.

1. Iron trade statistics.
2. Labor conditions and labor supply.
3. Patent rights.

F. Advances in the metallurgy of non-ferrous metals.

Section III: Applied Mechanics.

1. History of machine construction for mining and metallurgical purposes.
2. Steam raising.
3. Central electric power stations.
 - (a) Reciprocating engines (steam, gas).
 - (b) Turbo-engines.
4. Central condensing plant.
5. Winding engines.
 - (a) Steam winders.
 - (b) Electric winders.
 - (c) Safety and signalling apparatus.
6. Pumping.
7. Fans and air-compressors.
8. Blowing engines for blast-furnaces and steel works.
 - (a) Reciprocating blowers.
 - (b) Turbo-blowers.
9. Methods of driving rolling-mills.
10. Rolling-mills and accessories.
11. Conveyors for mining and smelting works.
 - (a) For materials in bulk (coal or coke).
 - (b) Special cranes and ladle-cars.
 - (c) Loading and unloading apparatus.

Section IV: Practical Geology.

1. Importance of practical geology in science and political economy.
2. Stratigraphy and genesis of the available mineral deposits. Calculations of their yearly output and resources.
3. Seismology, terrestrial magnetism, and terrestrial heat.
4. Questions relating to hydrology.
5. The utilization of natural sources of water power. Barrages.

The Committee on Organization request that applications for membership, accompanied by a remittance through the Post Office of the amount of the subscription, be made as soon as possible, in any case not later than Mar. 1, 1910. The remittance should be made payable to the "Stahlwerksverband A.-G. Düsseldorf, Kongress 1910."

Inquiries concerning membership in the Congress, announcement of proposed papers, length and time of presentation, suggestions, etc., may be addressed to Dr. E. Schrödter, Secretary of the Committee of the Congress, Düsseldorf, Jacobistrasse 3/5, Prussia.

Office Facilities for Visiting Members.

A separate room in the suite occupied by the American Institute of Mining Engineers on the ninth floor of the United Engineering Society Building, has been equipped with furniture and telephone extension for the temporary use of members of the Institute or of sister societies, or visitors suitably accredited.

Members of the Institute visiting New York for a short time, who need office facilities during their stay, or members residing in the city who need temporary office accommodation, can arrange to have set apart for their exclusive use a room, equipped with office furniture, telephone, etc., in the suite of the Institute. It is not the intention to give possession of the room to any individual for an indefinite time, but to offer to members of the Institute an opportunity to acquire a well-located, well-equipped business headquarters to carry on transactions which would not warrant the establishment of a permanent office. The room devoted to this purpose is entirely separate from the reception- and writing-rooms for the general use of the members. A small fee will be required for the use of the facilities furnished. For the conditions of this privilege, inquiry should be made at the office of the Secretary of the Institute.

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If you own a full set of the *Transactions*, this Index will make the whole of it instantaneously available without detailed research into each volume separately.

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to know more about, and perhaps to study. Thus, any person possessing this Index can ascertain at once what has been published in the *Transactions* on a given question, and can learn, by writing to the Secretary, what is its nature, whether it is still to be had in pamphlet form, where it can be consulted in a public library, at what cost it can be copied by hand, etc., etc.

In short, to those who own complete sets of the *Transactions*, this Index will be a great convenience; but to those who do not, it will be a professional necessity.

This volume is an octavo of 706 pages, containing more than 60,000 entries, duly classified with sub-headings, and including abundant cross-references. It has not been stereotyped, and the edition is limited to 1,600 copies. The price of the volume, bound in cloth, is \$5, and bound in half-morocco to match the *Transactions*, \$6. The delivery charges will be paid by the Institute on receipt of the above price.

Hydrographic Chart.

Owing to the great value to hydrographers of the chart contained in the paper, *A Graphic Solution of Kutter's Formula*, by L. I. Hewes and Joseph W. Roe (*Bulletin No. 29*, May, 1909, p. 454), a special edition for office or field use has been printed on durable cloth. Copies of this separate chart may be obtained, at a cost of 50 cents each, on application to the office of the Secretary of the Institute.

Special Notice.

Attention is respectfully requested to the announcement on pages 12 and 13 of the advertising section of this *Bulletin* concerning certain books and periodicals needed to complete sets in the Library.

Spokane Meeting.

Copies of the "Proceedings of the Spokane Meeting," printed in pamphlet form with special covers, may be obtained at a cost of 50 cents each, on application to the office of the Secretary of the Institute.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

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AMERICAN INSTITUTE OF MINING ENGINEERS.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays, from September 1 to June 30, and from 9 A.M. to 6 P.M. during July and August.

RULES.

For the protection and convenience of members, the following rules have been adopted:

The Secretary of each Society will, upon application, issue to any member of his Society in good standing a personal, non-transferable card, entitling him to the use of the Libraries in the alcoves of the Reading-Room.

This card, as well as any card of introduction given to a non-member, must be signed by the person receiving it, and surrendered at the desk at the time of its presentation. At every visit he must identify himself by signing his name in the registry.

Strangers who desire to enjoy the privilege of entering the alcoves are requested to present either letters of introduction from members, or cards, such as will be furnished upon application by the Secretary of each Society. The first two alcoves are free to all; and admission to the inside alcoves is given upon proper introduction.

The above rules apply to all persons except officers of the three Societies, personally known as such to the librarians.

The librarians are not permitted to lend to any person any catalogued pamphlet or volume, unless authorized in writing so to do by the Secretary or Chairman of the Library Committee of the Society to which the pamphlet or volume belongs.

Any person discovering a mutilation or defect in any book of the libraries is requested to report it to the librarian on duty.

Library Additions.

From Dec. 1 to Dec. 31, 1909.

[Copies of the list of additions to the Libraries of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers can be obtained on application to the Secretary of the American Institute of Mining Engineers.]

[**SECRETARY'S NOTE.**—In my notice of Professor Austin's book on *The Metallurgy of the Common Metals*, in the *Bulletin* for December, 1909, I said that the metallurgy of steel had been omitted from it altogether. This was an error, into which I was led, in my hasty examination of the book, by the circumstance that nothing about steel was given under "Iron," and that there was no separate title "Steel." I did not notice, under the head of "Refining," eight pages devoted to the refining of cast-iron, the puddling of pig-iron, the acid Bessemer process and the basic open-hearth process. The statements contained in these pages are intelligent and correct; and they entitle Professor Austin to claim that he has not altogether neglected this subject. But they do not constitute a comprehensive treatment of it, or possess in any degree the original value which, as I declared in my notice, pertains to other portions of his book.—R. W. R.]

ALMON DANFORTH HODGES AND HIS NEIGHBORS. Edited by Almon D. Hodges, Jr. Privately printed. Boston, 1909. (Gift of Amory G. Hodges and Almon D. Hodges, Jr.)

[**SECRETARY'S NOTE.**—The subject of this volume was born Jan. 25, 1801, at Norton, Mass., spent his maturer years in Providence and Boston, and died in 1878. For sixty years he kept a journal, which has furnished to the son who edits this volume abundant autobiographical material, and this material has been so illustrated and complemented by the filial zeal and literary skill of the editor as to make the book a graphic description of New England conditions during the period which it covers. Such chapters as "The Town of Norton in 1801," "An Old New England Clothier," *Apprentice Days*, etc., are admirable sketches of life and manners, and the chapter on The Dorr War of 1842 is a valuable contribution to history from one who, as a military commander, was an actor in that serious yet humorous episode. Colonel Hodges was an upright, able and influential citizen; and the frame in which his reminiscences are set puts his personality in effective relief. His son has well called him "a typical old New Englander." Belonging, as he did, to the times and ways "before the War," he was too old for military service in the field when that crisis came; but he gave to the Union army four sons, of whom one died in hospital and one in battle. The book is an unusually instructive and entertaining memorial, full of humor and inspiration.—R. W. R.]

AMERICAN MUSEUM OF NATURAL HISTORY. Bulletin. Vol. 26, 1909. New York, 1909. (Exchange.)

AMERICAN SOCIETY OF CIVIL ENGINEERS. Constitution and List of Members, 1909. New York, 1909. (Exchange.)

ANALYSE THERMIQUE ET MÉTALLOGRAPHIE MICROSCOPIQUE. By E. Rengade. Paris, Hachette et Cie., 1909. (Gift of Publishers.)

BERICHT DER SENCKENBERGISCHEN NATURFORSCHENDEN GESELLSCHAFT IN FRANKFORT AM MAIN, 1909. Frankfurt a/M., 1909. (Gift of Dr. James Douglas.)

- BIBLIOGRAPHY OF NORTH AMERICAN GEOLOGY FOR 1908, WITH SUBJECT INDEX. (Bulletin No. 409, U. S. Geological Survey.) By J. M. Nickels. Washington, 1909. (Exchange.)
- BRIEF DESCRIPTION OF THE WASHOE SMELTER, AUGUST, 1909. Anaconda, 1909. (Gift of the Anaconda Copper Mining Co.)
- BRITISH STANDARD SPECIFICATIONS FOR INGOT STEEL FORGINGS FOR MARINE PURPOSES. (Engineering Standards Committee, Publication No. 29.) London, 1909. (Exchange.)
- CALIFORNIA STATE MINING BUREAU. Bulletin Nos. 54, 55. San Francisco, 1908. (Exchange.)
- CEMENT RESOURCES OF VIRGINIA WEST OF THE BLUE RIDGE. By R. S. Bassler. Charlottesville, 1909. (Gift.)
- CENTRALBLATT FÜR MINERALOGIE, GEOLOGIE UND PALÄONTOLOGIE, 1908. Stuttgart, 1908. (Purchase.)
- CHEMICAL, METALLURGICAL, AND MINING SOCIETY OF SOUTH AFRICA. List of Members, 1909. Johannesburg, 1909. (Exchange.)
- COST OF MINING. By J. R. Finlay. New York, McGraw-Hill Book Company, 1909. Price, \$5 net. (Gift of Publishers.)

[SECRETARY'S NOTE.—This book belongs to a class heretofore too scantily represented in our mining literature. From time to time articles or paragraphs giving more or less accurate estimates of mining-costs at specified localities appear in the technical journals or in professional papers. Even a compilation of such scattered material, like the book on "Economics of Mining," published in 1905 under the editorship of Mr. T. A. Rickard, and composed of contributions by sundry authors (including Mr. Finlay) to the *Engineering and Mining Journal*, is greatly useful; but this book may claim a higher value, as a critical summary of the subject from the hand of an expert, who has not merely collected, but also sifted and judged, his crude material, and who accompanies the statement of his results with a helpful exposition of principles. One reason, I fancy, for the dearth of such books is, that the costs of mining constantly vary even in the same locality, according to changes in physical conditions, machinery, methods and wages. It has doubtless seemed to mining engineers almost a waste of time to chronicle figures as problematic and ephemeral; and the consequence has been, to a large extent, that such figures have been presented chiefly in the sanguine prospectuses of new enterprises, or buried beyond recognition in the particular system of book-keeping followed by this or that mining company. Yet this question of mining-costs is one which the young mining engineer ought specially to understand. And it is not enough that he should be *told* what the mining-costs in a given locality, at a given time, actually are. Such information may be valuable, in proportion to its accuracy and authority. But it is more important that he should be enabled to *find out*, for himself, by the study and analysis of confused or incomplete data, what these costs, in a given case, are.

Mr. Finlay, qualified by 20 years' practical experience in mining, supplied by technical literature and much correspondence with the necessary material, and further trained by the discipline of his work as a lecturer at Harvard University on the economics of mining (a discipline which, as I may be permitted to say, seems to be an invaluable, if not indispensable, preparation for technical authorship), has produced a treatise which furnishes, not only well-considered data of present practice, but also guidance for the intelligent criticism of the reports of future practice. His book contains, besides its helpful introductory chapters on the value of mining-property, the factors governing variations of cost, and the

difference between "partial" and "complete" costs, separate discussions of economic conditions in coal-mining; Lake Superior iron-mining; copper-mining at Lake Superior, and in Montana, Australia, Arizona, Mexico, etc.; the mining of lead- and silver-lead ores; and the mining of gold and silver in various forms and localities. Mr. Finlay's expositions of principles and his discussions of varied conditions are characterized by logical acuteness and practical sense of relation and perspective. His distinction between "partial" and "complete" costs is particularly useful, though it is to be regretted that he has used, to a considerable extent, as a synonym for the latter, the much less clear and satisfactory term, "selling costs," by which he means, in fact, selling prices, which will cover all costs, including that of the amortization of capital with interest. The phrase is meaningless, without the author's explanation; and with that explanation, it becomes unnecessary. But this is not the place for such criticisms. The readers of this book will be in no danger of misunderstanding it; and its propositions are both sound and timely.—R. W. R.]

DESCRIPTIVE SKETCH OF THE GEOLOGY AND ECONOMIC MINERALS OF CANADA.

By C. A. Young. Ottawa, 1909. (Exchange.)

ECOLOGICAL SURVEY OF ISLE ROYALE, LAKE SUPERIOR. Lansing, 1909. (Exchange.)

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GEOLOGY OF THE DISSEMINATED LEAD DEPOSITS OF ST. FRANCOIS AND WASHINGTON COUNTIES. (Missouri. Bureau of Geology and Mines, Vol. IX., parts 1-2. By E. R. Buckley.) Jefferson City, 1908.

GEOLOGY OF THE LEWISTOWN COAL FIELD, MONTANA. (Bulletin No. 390, U. S. Geological Survey.) By W. R. Calvert. Washington, 1909. (Exchange.)

GRANITE-BIMETALLIC CONSOLIDATED MINING COMPANY. Annual Report, 1907, 1908. St. Louis, 1908, 1909. (Gift of Granite-Bimetallic Consolidated Mining Company.)

INSTITUTION OF MINING AND METALLURGY. General and Personal Index to Transactions, Vols. 1-15, 1892-1906. London, 1909. (Purchase.)

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IRON AND STEEL INSTITUTE. Carnegie Scholarship Memoirs. Vol. 1. London, 1909. (Exchange.)

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JURIS METALLICI, UBER BERG RECHTS SPIEGEL. N. p., 1698. (Purchase.)

MERCURY MINERALS FROM TERLINGUA, TEXAS. (Bulletin No. 405, U. S. Geological Survey.) By W. F. Hillebrand and W. T. Schaller. Washington, 1909. (Exchange.)

MINING ENGINEERING AND MINING LAW. By J. D. Hague. (Reprinted from *Engineering and Mining Journal*, Oct. 20, 1904.) (Gift.)

MONOGRAPHIC REVISION OF THE TWISTED WINGED INSECTS COMPRISING THE ORDER STREPSIPTERA KIRBY. (Smithsonian Institution. U. S. National Museum. Bulletin No. 60.) By W. D. Pierce. Washington, 1909. (Exchange.)

- NEUES JAHRBUCH FÜR MINERALOGIE, GEOLOGIE UND PALÄONTOLOGIE. Vols. 1-2, 1908. Stuttgart, 1908. (Purchase.)
- NOTES ON SOME MINING DISTRICTS IN HUMBOLDT COUNTY, NEVADA. (Bulletin No. 414, U. S. Geological Survey.) By F. L. Ransome. Washington, 1909. (Exchange.)
- PETROLEUMS AND COALS. (*Canadian Mining Institute Journal*.) By E. Coste. Montreal, 1909. (Exchange.)
- PLEISTOCENE GEOLOGY OF THE LEADVILLE QUADRANGLE, COLORADO. (Bulletin No. 386, U. S. Geological Survey.) By S. R. Capps, Jr. Washington, 1909. (Exchange.)
- PRIMER OF EXPLOSIVES FOR COAL-MINES. (Bulletin No. 423, U. S. Geological Survey.) By C. E. Munroe and Clarence Hall. Washington, 1909. (Exchange.)
- PRODUCTION OF COAL, COKE, AND PEAT IN CANADA, 1907-1908. Ottawa, 1909. (Exchange.)
- PRODUCTION OF NATURAL GAS AND PETROLEUM IN CANADA, 1907-1908. Ottawa, 1909. (Exchange.)
- REPORT OF THE NATIONAL CONSERVATION COMMISSION, FEBRUARY, 1909. Washington, 1909. (Gift.)
- REPORT ON BRITISH STANDARD PIPE THREADS FOR IRON OR STEEL PIPES AND TUBES. (Engineering Standards Committee, Publication No. 21, revised.) London, 1909. (Exchange.)
- REPORT ON THE IRON-ORE DEPOSITS ALONG THE OTTAWA (QUEBEC SIDE) AND GATINEAU RIVERS. By F. Cirkel. Ottawa, 1909. (Exchange.)
- REPORT ON THE GOLD, DIAMOND, AND FOREST INDUSTRIES OF BRITISH GUIANA, 1908-1909. Georgetown, 1909. (Gift of Institute of Mines and Forests of British Guiana.)
- REPORT ON THE MINING-INDUSTRY OF NATAL, 1907-1908. Pietermaritzburg, 1909. (Exchange.)
- SEWERAGE, WATER, AND DRAINAGE SYSTEM OF NEW ORLEANS. By G. G. Earl. N. p., n. d. (Gift of Howard Memorial Library.)
- SKETCH OF THE GEOGRAPHY AND GEOLOGY OF THE HIMALAYA MOUNTAINS AND TIBET. Parts 1-3. By S. G. Burrard and H. H. Hayden. Calcutta, 1907. (Gift of India Geological Survey.)
- THE SOUTH IN THE BUILDING OF THE NATION. History of the Southern States, Designed to Record the South's Part in the Making of the American Nation. Vol. I. Richmond, 1909. (Gift of Southern Publication Society.)
- STATISTIK DES BERGBAUES IN ÖSTERREICH. Pt. 3, 1907; Pt. 1, 1908. Wien, 1909. (Exchange.)
- TASMANIA. MINES DEPARTMENT. Report of the Secretary for Mines, 1908. Tasmania, 1909. (Exchange.)
- TEXT-BOOK OF ORE DRESSING. By R. H. Richards. New York, McGraw-Hill Book Company, 1909. (Gift of Publishers.)

[SECRETARY'S NOTE.—When I noticed, in the *Bulletin* for December, 1909, Vols. III. and IV. of Professor Richards's great treatise, I did not know that he had already prepared the condensed summary in a single volume, which I then characterized as desirable. It is fortunate that Professor Richards himself has been able to superintend this "concentration" of his larger work. Nobody else could know so well what to omit, what to emphasize and what to generalize, for the purpose of a manual adapted to the use of students and instructors. For details of practice, descriptions of many mills not typical, historical data, and

bibliography, the reader will have to consult the previous work. But this volume contains an additional chapter on coal-washing, which describes the principal machines and methods used in preparing coal for coking and for the market, and discusses in detail a few types of bituminous-coal washeries.

It is hardly permissible to call any book a "classic," until the lapse of time has shown that it cannot be superseded or forgotten in its particular department. But this book, and the great work of which it is a summary, constituting as they do the monument of a long professional career of incessant, devoted and intelligent labor, would be classical now, if they were old enough.—R. W. R.]

TRANSVAAL. MINES DEPARTMENT. Report of the Geological Survey, 1908. Pretoria, 1909. (Exchange.)

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CARNEGIE LIBRARY OF PITTSBURGH. Metal Corrosion and Protection. Ed. 2.
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- CUSHMAN, A. S.** Preservation of Iron and Steel. (U. S. Dept. of Agriculture.
 Office of Public Roads. Bulletin No. 35.) Washington, 1909.
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- Excluding and Rust Inhibiting Properties of Paint Pigments for the Protection of Steel and Iron. 1909.
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- First Annual Report on Atlantic City Steel Test Fence. 1909.
- First Annual Report on Wearing of Paints Applied to Atlantic City Test Fence. 1909.
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- Laboratory Study of Panels of Atlantic City and Pittsburgh Test Fences.
- Preliminary Report on Steel Test Fences. 1908.
- Recent Technical Developments in Paint Manufacture.
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- Protective Coatings for Conservation of Structural Materials.
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TRADE CATALOGUES.

- ANACONDA COPPER MINING Co.,** Anaconda, Mont. Catalogue of high-grade silica fire-brick, fire-clay brick, silica, and clay tile, as well as important information regarding refractories. 76 pages.
- CYANIDE PLANT SUPPLY Co.,** San Francisco, Cal. The Parrish Continuous Filter. Articles: The Filtration of Slime; Continuous Collection of Sand for Cyaniding; The Parrish Filter as a Dewaterer. 16 pages.
- DILLON-BOX IRON WORKS Co.,** Denver, Colo.
 Twenty horse-power electric hoist. 1 page.
 Fifty horse-power electric hoist. 1 page.
 Two hundred and twenty-five horse-power electric hoist. 1 page.
- DINGS ELECTRO MAGNETIC SEPARATOR Co.,** Milwaukee, Wis. Bulletin No. 21, on magnetic ore-separators. 20 pages.
- GENERAL ELECTRIC Co.,** Schenectady, N. Y.
 Electrical measuring instruments. 7 pages.
 Price-list applying to 1909 Supply Catalogue of supplies carried by the General Electric Co. 507 pages.
Supplement Bulletin No. 1, on arc lighting, arc-light hangers, and cut-outs. 5 pages.
 Train-lighting with G. E. tungsten and tantalum lamps. 5 pages.
- GREEN FUEL ECONOMIZER Co.,** Matteawan, N. Y.
The Book of the Economiser, being a treatise on the history, theory, practice, and manufacture of economizers. 158 pages.

- Bulletin No. 105 on drying brick and tile. 16 pages.
 Bulletin No. 108 on mechanical draft apparatus. 16 pages.
 Bulletin No. 109 on heating and ventilating buildings. 16 pages.
 Bulletin No. 112 on economical heating of water and air in breweries and malt-houses. 16 pages.
 Bulletin No. 113 on Green fuel economizers at the Manhattan Power Station of the Interborough Rapid Transit Co., New York City. 8 pages.
 Bulletin No. 114 on Green's vertical automatic engines for driving fans, blowers, and exhausters. 4 pages.
 Bulletin No. 115 on Green's vertical throttling engines for driving fans, blowers, and exhausters. 4 pages.
 Bulletin No. 121 on automatic draft control for steam boiler furnaces. 8 pages.
 Bulletin No. 122 on uses and advantages of the Green fuel economizer. 16 pages.
 Bulletin No. 123 on the Green patent waste-heat air-heater. 15 pages.
 Bulletin No. 124 on horizontal steam engines for driving fans, blowers, and exhausters. 7 pages.
 Bulletin No. 126 on drying in industrial plants. 32 pages.
 A catalogue of fans, blowers, and exhausters for all purposes, including plain-mill exhausters. 96 pages.

JEFFREY MANUFACTURING CO., Columbus, O.

Elevating, conveying, and power-transmitting machinery and chains. 368 pages.

Bulletin No. 18 on Jeffrey electric- and air-power coal-cutters. 32 pages.

J. GEO. LEYNER ENGINEERING WORKS, Littleton, Colo. Leyner Bulletin No. 1010, devoted to the interests of the Leyner drill department. 8 pages.

NATIONAL X-RAY REFLECTOR CO., Chicago, Ill. Reprint from the *Fine Arts Journal*, article: A New Light for Art Galleries, Libraries, and Museums; and article: Development of Indirect Illumination. 7 pages.

ORE CONCENTRATION CO., London, Eng. List of pamphlets on the Elmore Vacuum Process, published by the Ore Concentration Co. 3 pages.

PENTON PUBLISHING CO., Cleveland, O. November, 1909, list of machinery, positions, situations, and information useful to engineering interests. 11 pages.

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MANUFACTURERS' RECORD'S ANNUAL BLUE-BOOK OF SOUTHERN PROGRESS, 1909. Baltimore, 1909. (Gift of Manufacturers' Record).

ILLUSTRATIONS OF CONCRETE STEEL ARCH BRIDGES. (Gift of Concrete Steel Engineering Company.)

TRADE CATALOGUES.

AMERICAN MACHINE CO., Louisville Ky.

Full magnet control electric elevators for passenger and freight service. 14 pages.

Description of American Ammonia Regulator for refrigerating machines. 2 pages.

Description of American Dehydrator for ice and refrigeration machines.
2 pages.

The absorption system of ice making compared to the compression system.
2 pages.

Catalogue of ice and refrigerating machinery, absorption system. 37 pages.
VILTER MANUFACTURING CO., Milwaukee, Wis.

April, 1909, partial list of users of improved ice-making and refrigerating
machinery. 62 pages.

July, 1909, catalogue A of refrigerating and ice-making machinery. 61
pages.

Catalogue F of ammonia fittings for refrigerating and ice-making plants.
112 pages.

MEMBERSHIP.

NEW MEMBERS.

The following list comprises the names of those persons elected as members who accepted election during the month of December, 1909:

Members.

Donald J. Browne,	Roseland, B. C., Can.
John Marshall Cairns,	Glasgow, Scotland.
Samuel W. Cohen,	Cobalt, Ontario, Can.
Raoul Geer Dufourcq,	Arizpe, Sonora, Mex.
James Harold Hance,	Salt Lake City, Utah.
Frederick Charles Holmes,	Santiago de Cuba, Cuba.
Clarence T. Hopkins,	Jerome, Ariz.
Archabald Stewart Hummell,	High Bridge, N. J.
Percy Kenyon,	Concepcion del Oro, Zacatecas, Mex.
Warren Lawson Kluttz,	Thomas, Ala.
S. Arthur Krom,	Plainfield, N. J.
Henry M. Lancaster,	Wallace, Idaho.
Charles N. Lindley,	New York, N. Y.
Robert Livingstone,	Edmonton, Alberta, Can.
Eugene McAuliffe,	Chicago, Ill.
James F. McCarthy,	Wallace, Idaho.
Atholl Francis McEwen,	Cobalt, Ontario, Can.
Henry A. Morin,	Gowganda, Ontario, Can.
Duncan M. Munro,	Hostotipaquillo, Jalisco, Mex.
James Negus,	Boppy Mountain, N. S.W., Australia.
John O. Norbom,	Berkeley, Cal.
Horace F. Parsons,	Garfield, Utah.
John G. Perry,	Denver, Colo.
Guy Hall Ruggles,	Santa Rita, N. M.
Chard Oliver Sanford,	Goldroad, Ariz.
Charles H. Schlacks,	San Francisco, Cal.
Gustave Schrader,	Sutter Creek, Cal.
Tsok Kai Tse,	Wickenburg, Ariz.
Rush J. White,	Wallace, Idaho.

Associate.

James F. Callbreath, Jr., Denver, Colo.

CANDIDATES FOR MEMBERSHIP.

The following persons have been proposed for election as members of the Institute during the month of December, 1909. Their names are published for the information of mem-

bers and associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or unfavorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Council, which has the power of final election.

Members.

Richard E. Armstrong,	Salt Lake City, Utah.
Alfred William Bleeck,	Rangoon, Burma, India.
Gilmour Ewing Brown,	Ballock, Dumbartonshire, Scotland.
Marco Chiapponi,	New York, N. Y.
James B. Cook,	Horatio, Pa.
Carl F. Dietz,	Boston, Mass.
Archibald David Gilchrist,	Ballarat, Victoria, Australia.
Thomas S. Harrison,	Cheyenne, Wyo.
Henry Edson Judd,	New York, N. Y.
Dyke Vinton Keedy,	Boston, Mass.
Frank Caspar Laurie,	Coatzacoalcas, Mexico.
Charles Frank Parry,	Germiston, Transvaal, S. Africa.
Harrison Prindle,	Buffalo, N. Y.
Edward W. Ralph,	Kimberly, Nev.
Arthur M. Swartley,	Sunbeam, Idaho.
Whitman Symmes,	Virginia City, Nev.
John Tyssowski,	New York, N. Y.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address on Records, from which Mail has been Returned.
Alexander, George E.,	Sparta, Ore.
Andersen, Carl,	Johnnie, Nev.
Badger, Harry S.,	Goldboro, N. S., Can.
Bartocchini, Astolfo,	214 E. 90th St., New York, N. Y.
Bassett, Thomas B.,	Cumpas, Sonora, Mexico.
Batchelder, Joseph F.,	54 1st St., Portland, Ore.
Bellam, Henry L.,	Reno, Nev.
Bouchelle, James F.,	22 Duncan Ave., Jersey City, N. J.
Brown, Frank H.,	Coppermount, Alaska.
Campa, Jose,	Mexico City, Mexico.
Cragoe, A. Spencer,	Vencedora, Mexico.
Derby, Harry S.,	134 Monroe St., Chicago, Ill.
Dickson, George H.,	Lethbridge, Alberta, Canada.
Donnewald, Albert H.,	3709 Finney Ave., St. Louis, Mo.
Dougherty, Clarence E.,	41 Wall St., New York, N. Y.
Downs, M. E.,	25 Broad St., New York, N. Y.
Ekberg, Benjamin P.,	Johannesburg, Transvaal, So. Africa.
Field, Wilfrid B.,	Mexico City, Mexico.

Gage, Edward C.,	San Dimas, Dur., Mexico.
Gaines, Ambrose P.,	Dayton Coal & Iron Co., Dayton, Tenn.
Gee, Emerson,	Reno, Nev.
Hawkins, Tancred,	Ballydehob, Ireland.
Herr, Irving,	47 Prentiss St., Cambridge, Mass.
Hodge, Benjamin,	St. Francis Hotel, Denver, Colo.
Hunt, Thatcher R.,	Iron Mt., via Keswick, Cal.
Jewett, Eliot C.,	2918 Morgan St., St. Louis, Mo.
Kow, Tong Sing,	Shanghai, China.
McGregor, J. Murray,	Tokyo, Japan.
Mentzel, Charles,	Copperhill, Tenn.
Mildon, Reginald B.,	Nacozari, Son., Mexico.
Mills, Ronald V. A.,	20 Union Sq., New York, N. Y.
Moulton, Herbert G.,	Cobalt, Ont., Can.
Muir, Thomas K.,	Portland, Ore.
Parrish, Samuel F.,	Georgetown, Idaho.
Perkins, Walter G.,	McGill, Nev.
Piper, John W. H.,	Buenos Ayres, Argentine Rep., S. A.
Potter, J. A.,	41 W. 124th St., New York, N. Y.
Sandifer, Harmer C.,	El Oro, Mexico.
Schlemm, William H.,	Durango, Mexico.
Scott, Winfield G.,	Long Beach, Cal.
Skelding, Joseph F.,	Embreeville, Tenn.
Thomas, Richard A.,	43 Wall St., New York, N. Y.
Vidler, Louis W.,	Lookout Mountain, Colo.
Warren, Henry L. J.,	Salt Lake City, Utah.
Wetmore, E. A.,	Marysville, Mont.
Wilson, Odell,	Shingle, Cal.
Wolfe, Burton L.,	Ely, Nev.
Young, William,	Kenora, Ont., Canada.

NECROLOGY.

The deaths of the following members have been reported to the Secretary's office during the month of December, 1909:

Date of Election.	Name.	Date of Decease.
1905.	*William Adams,	December 8, 1909.
1878.	**Dr. Charles B. Dudley,	December 21, 1909.
1888.	*Richard Fames, Jr.,	December 15, 1909.
1880.	*George G. Francis,	— — — 1907.
1888.	*Alphonse Hennin,	August 18, 1908.
1875.	*William Metcalf,	December 5, 1909.
1875.	††Israel W. Morris,	December 18, 1909.
1896.	*John W. Nesmith,	December 17, 1909.
1873.	*William H. Singer,	September 4, 1909.

* Member. ** Life member. †† Life associate.

BIOGRAPHICAL NOTICES.

William Adams was born Feb. 28, 1849, at Burtington, Wis. He became a member of the Institute in 1906, at which time he had had about 30 years' practical experience in mining. From 1874 to 1878, he was miner, millman and assayer at the Indian Queen, near Candelaria, Nev., and in 1878 he became manager. Subsequently, he was for two years a consulting engineer at Prescott, Ariz. Still later, going to Broken Hill, N. S. Wales, he became in 1887 and remained for two years general manager of the Broken Hill Junction Silver Mining Co. Then he spent four years in explorations and examinations for English capitalists in Western Australia, followed by three years of similar work in China and Corea. About 1899 he went to Chihuahua, Mex., where he became manager of the Santa Eulalia Mines Investment Co. He died in the city of Chihuahua, Dec. 8, 1909.

Robert Stewart Brooks was born at Paterson, N. J., and, at the outbreak of the Spanish War, was a student of civil engineering at Princeton University. He left college to enlist as a private in the U. S. Volunteers, and won in Cuba the rank of First Lieutenant of Volunteer Engineers. In this capacity he took an active part in the sanitary improvement of Havana. Princeton gave him his degree with his class in 1896, and, resigning from the army, he served first as assistant engineer on hydraulic work of the Jersey City Water Supply Co., and afterwards as contractors' engineer in charge of the construction of a masonry dam across the Genesee river at Mt. Morris, N. Y. About 1901 he went to Arizona, and, desiring to gain a thorough acquaintance with all kinds of mining work, entered the employ of the Copper Queen Consol. Mining Co., where he worked in the successive positions of mucker, carman, and miner, and was placed at last in charge of sampling- and assaying-work at the Old Dominion mine of the company at Globe, Ariz. During this period he made many field-examinations for the Guggenheim Exploration Co., Dr. L. D. Ricketts and Col. W. C. Greene, and in February, 1906, when he became a member of the Institute, he was Superintendent of the Ocampo mines of the Greene Gold-Silver Co., Ltd., in Chihuahua, Mex. In 1907, he went to Cananea, Sonora, as an em-

ployee of the Greene-Cauanea Copper Co. On July 6, 1909, during an exploring-trip with a pack-train in the Yaqui country, Mr. Brooks was swept from his horse while fording the Yaqui river; and his body was found two months later ninety miles below the ford. His funeral was held Nov. 26, 1909, in his birthplace, Paterson, N. J., in the home of the "Elks"—of a branch of which society in El Paso, Texas, he was a member.

Richard Eames, Jr., was born June 3, 1859, at Brooklyn, N. Y. At the age of sixteen, he became an assistant of his father, Dr. R. M. Eames, then State Geologist of Minnesota. From 1877 to 1882, he was engaged in exploring and mining in North Carolina, incidentally making examinations of mines in Nevada, California, etc. In 1879, he established his headquarters at Salisbury, N. C., which continued to be his home, with intervals of professional work elsewhere, until his death. Thus for a while, in 1883, he was manager of a gold-mine in Honduras, and subsequently examining gold-deposits in New Hampshire, etc. In 1886-8, he was connected with graphite-mines in Rhode Island, the examination of gold- and silver-mines in the San Juan district of Colorado, and the management of the Copper Knob mine and mill. In 1887 he became consulting metallurgist for the Indian Gold Mines, Madras, India, and in succeeding years manager of several North Carolina mines, and consulting or directing engineer of mines and smelters in Arizona. He also visited Mexico in a professional capacity. But North Carolina was his chosen field; and few equaled him in his knowledge of the economic geology and the mining industry of that region. He was at one time active as a collector of ores and minerals for the N. C. Geological Survey; and he established in Salisbury the Salisbury Supply & Commission Co., dealing in mining and other machinery. In this thriving enterprise he was chiefly engaged at the time of his death, which occurred Dec. 15, 1909, in a wreck on the Southern Railway, near Greensboro, N. C. Mr. Eames was widely known and highly esteemed, and the tidings of his sudden death were received with universal regret. He became a member of the Institute in 1888.

The Girod Electric Furnace, and the French Works Using the Paul Girod Steel-Process.*

BY DR. WILHELM BORCHERS.†

(Pittsburg Meeting, February, 1909.)

IN all special branches of the chemical and metallurgical industries, in which large electric furnaces became necessary for carrying out new processes or for the improvement of old ones, the development of the electric furnaces took place on much the same lines. The endeavors to make a success of a new idea brought forth many ingenious designs, which, however, almost without exception, furnished the proof that the safest and shortest way to practical success is the utmost simplicity of construction of the necessary apparatus.

Our knowledge of the qualities of materials for building electric furnaces and of the constituents of the furnace-charges, especially their electric conductivity and their chemical affinity towards one another at high temperatures, is still far from being complete, and from this fact we must conclude that the smaller the number of elements in the construction of a furnace, the fewer the number of unreliable factors both in the construction and in the operation of the electric furnace.

This conclusion deserves special attention when an electric furnace for making steel has to be chosen from the constantly growing number of inventions, inasmuch as the chief constituent of steel, the element iron, is a substance which in its liquid phase has so great an affinity for those elements which are to be removed from the charge, that it is very difficult to comply with the following conditions: 1, to heat the refining-slag to the highest point of its chemical activity; 2, to prevent the iron from entering the slag, or, where this cannot be done, to make it enter so that it finally appears in the end-product

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† Professor of Metallurgy, Royal College of Technology, Aachen, Germany.

without material loss; 3, to select and arrange the materials from which the furnace is to be built, so that wherever contact with the furnace-charge cannot be avoided, these materials will not react upon the constituents of the charge in an injurious way.

About six years ago, in my review of the electrode furnaces up to that time,¹ I could say that a furnace simpler than the Héroult furnace could not be found, but to-day I have to correct this statement. At the present time the Girod furnace must be recognized as the simplest and safest, both in construction and operation, of all electrode furnaces.

As far as I am from changing my good opinion of Dr. Héroult's achievements in electro-metallurgy, I consider it my duty as professor of electro-metallurgy, and as an author of electro-metallurgical books and other scientific publications, to correct publicly opinions of former stages of scientific progress, which have been superseded by a better knowledge.

After having perceived the advantages of the Girod electric heating-system for my laboratory research-work, I was glad to accept several invitations of Director Paul Girod to visit, a few years ago, his old works owned by the Société Anonyme Electrometallurgique Procédés Paul Girod, and, to-day, the new steel-works owned by the Compagnie des Forges et Aciéries Electriques Paul Girod, both at Ugine, Savoie, France, especially since I received permission to make free use of my studies at Ugine for my lectures and publications.

The Girod furnace is the simplest of modern electric steel-furnaces. It is useful both as an experimental furnace and as a smelting-works furnace on a large scale. I am using it in my laboratory with currents of from 30 to 36 kw., and for steel-smelting it is being used with currents of 300 and 1,200 kw. It is a combination of resistance and arc heating-furnace. The metal to be smelted, which acts as one of the electrodes, is covered by the refining-slag as an electrolytic conductor, and a carbon block (or several carbon blocks), entering from above through the cover of the furnace, forms the opposite electrode above the center portion of the bath. The arcs play between the carbon blocks and the slag, and no doubt the largest amount of heat is here produced. A second heat-producing place is the

¹ Borchers, *Electro-Metallurgie*, vol. iii., p. 536 (1903).

layer of slag, through which the current passes to and from the metal. Last but not least, the metal itself becomes an important heat-producer on account of the effective manner in which the electric current is made to pass through the molten metallic body, and this is the most important feature of the Girod process.

The distribution of the electric current through the molten metal is clearly shown in Figs. 1 and 2, in which *A* is the

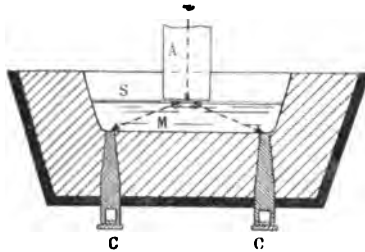


FIG. 1.—SECTION OF GIROD FURNACE, SHOWING THE DISTRIBUTION OF THE ELECTRIC CURRENT.

carbon electrode; *S*, the slag; *M*, the molten metal; and *C*, contact-pieces to connect the metal with the current-conductor. The contact-pieces are of such cross-section and length that each one will take up only a certain part of the whole current without being excessively heated, and therefore without exceed-

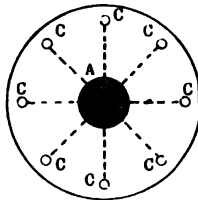


FIG. 2.—PLAN OF GIROD FURNACE, SHOWING THE DISTRIBUTION OF THE ELECTRIC CURRENT.

ingly increasing its resistance. An additional regulation of the temperature and resistance of each contact-piece is effected by cooling-water circulating through small chambers in the end. The contact-pieces are made of pure iron in order to avoid any deterioration of the furnace-charge. They act as the connecting-rods between the furnace-charge and the current-generators, and also regulate the distribution of the current, so that the electric charges pass uniformly from and to the centrally-

THE GIROD ELECTRIC FURNACE.

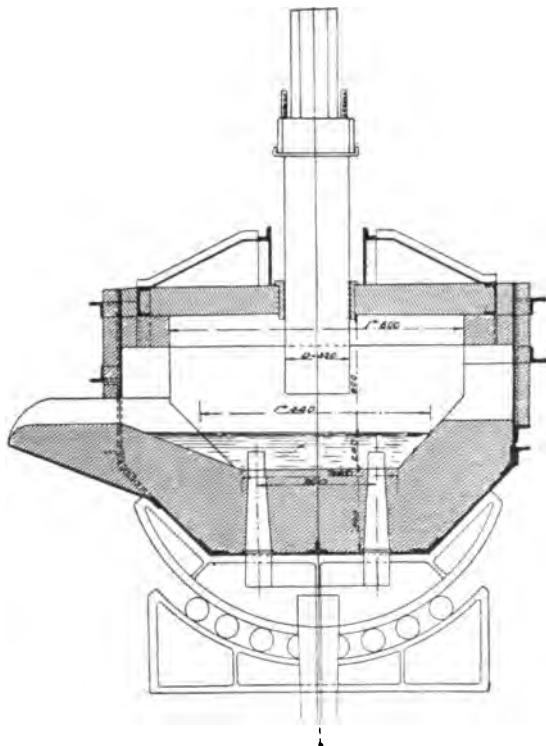


FIG. 3.—SECTION OF 2.5-TON GIROD ELECTRIC FURNACE.

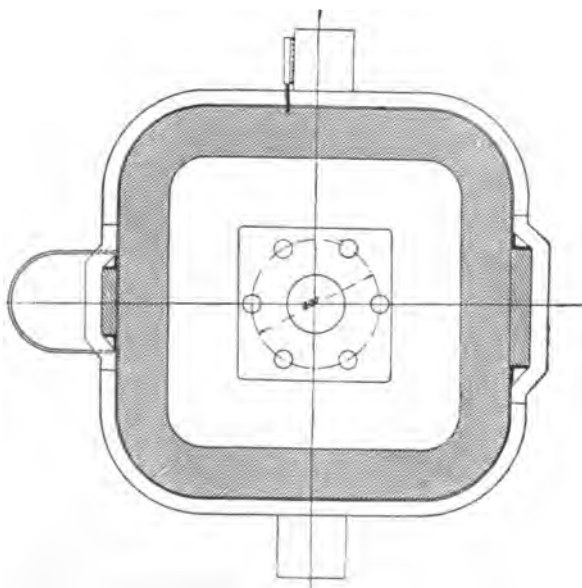


FIG. 4.—PLAN OF 2.5-TON GIROD ELECTRIC FURNACE.

hanging carbon rod or rods in radial direction to and from the periphery of the bath. This condition is important, not only for uniformly heating the bath, but also for keeping every part of the liquid metal in constant motion. Running a furnace with as high a current-density as is found necessary to smelt iron and steel, one can easily observe that the passage and the transformation of the electric current into heat are accompanied by a violent mechanical motion of all particles of the liquid. This movement, however, accelerates the contact between the

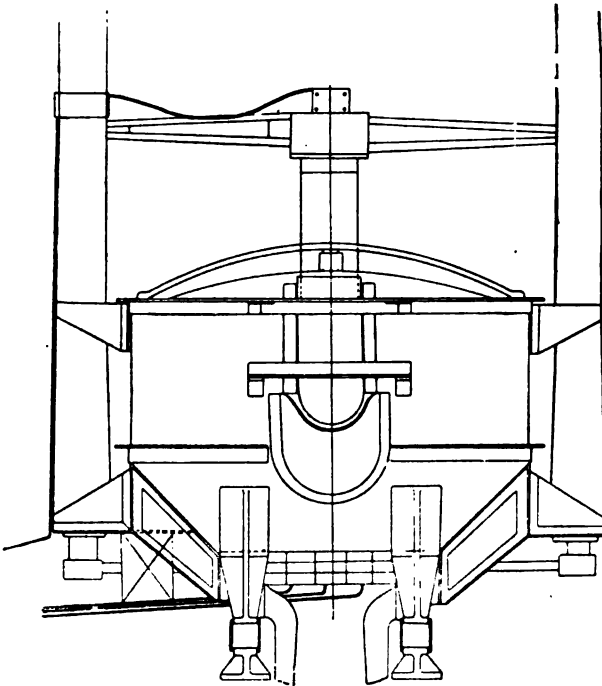


FIG. 5.—SECTIONAL ELEVATION OF 2.5-TON GIROD ELECTRIC FURNACE.

impurities of the iron and the refining-slag which floats on top of the bath. The Girod system of arranging the electrodes and contacts is a safeguard against any stagnation of parts of the liquid furnace-charge, and for this reason the advantages of both the induction or transformer furnaces and the electrode furnaces are combined in the Girod furnace, while the imperfections of either type have been overcome.

The arrangement of electrodes and contacts in the Girod furnace gives it a special advantage over other electrode fur-

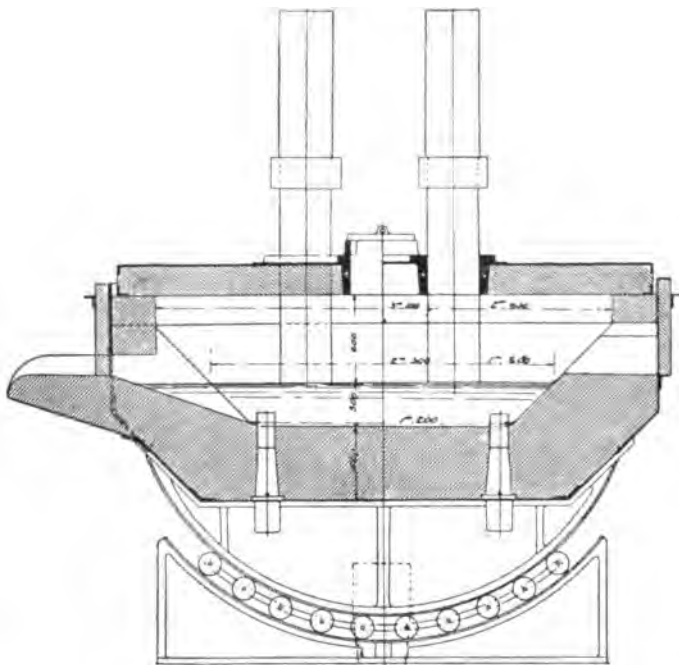


FIG. 6.—SECTION OF 12-TON GIROD ELECTRIC FURNACE.

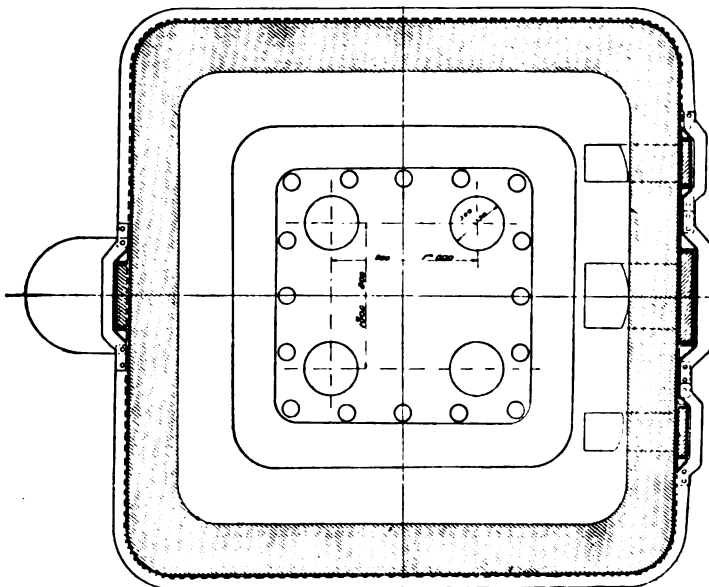


FIG. 7.—PLAN OF 12-TON GIROD ELECTRIC FURNACE.

naces during the melting of cold scrap. As soon as the charge is on the hearth of the furnace, the upper electrode is lowered until it rests upon the heap of scrap; the current finds no other way than from the center of the heap, by means of numerous small arcs through the whole mass of scrap, to the periphery of the heap on the hearth-bottom. The heap is breaking down simultaneously in all parts in a very short time. There is no sticking of cold pieces to the bottom of the furnace, and therefore no necessity to stir up and loosen such lumps from the hearth, which would endanger the latter.

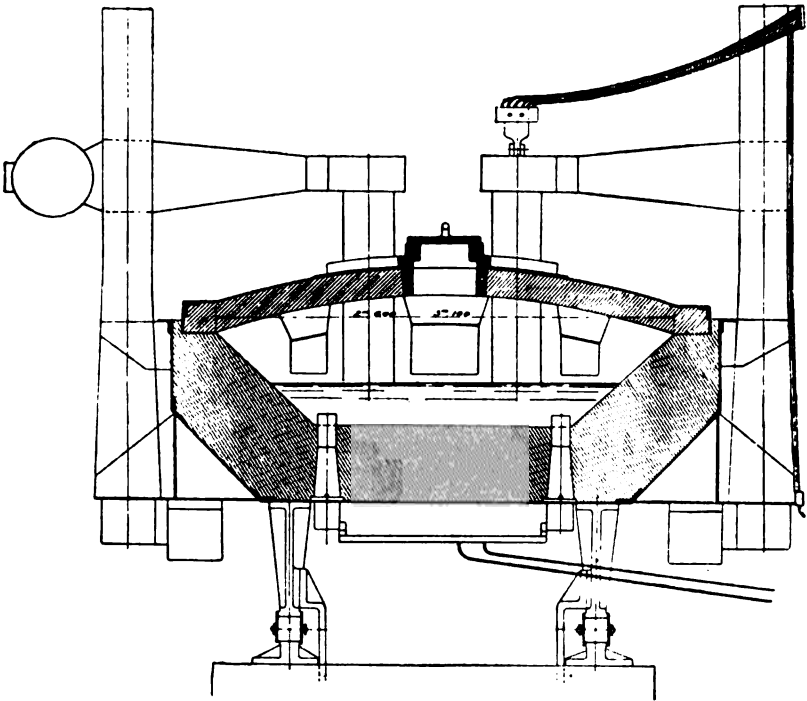


FIG. 8.—SECTIONAL ELEVATION OF 12-TON GIROD ELECTRIC FURNACE.

The sketches of the Girod furnace, Figs. 3 to 8, illustrate the construction. Figs. 3, 4, and 5 are plans and sections of a 2.5-ton furnace; Figs. 6, 7, and 8, of a 12-ton furnace. The most important dimensions are given in the metric system.

During a smelting-operation, if pieces of the ends of the contact bodies melt and dissolve in the steel, no harm will be done to the latter, since the contacts consist of pure iron, and as the quantity of iron, which in such a case combines with the liquid charge of the furnace, is proportionally so small that the

qualities of the charge will not be influenced thereby to any perceptible degree.

The applicability of the Girod furnaces is not restricted by the nature of the raw materials, which may be either cold scrap or molten metal. In feeding cold scrap the whole charge is not added at once. After the larger part of the charge has been shoveled or otherwise thrown upon the hearth, the current is sent through the heap in the manner already described. The rest of the charge is put into the furnace, together with the first batch of the refining ingredients. Taking the run of a 2-ton furnace as an example, the charge consists of from 2,000 to 2,500 kg. of iron scrap, and the first batch of refining-slag usually consists of about 80 kg. of lime, CaO , and from 220 to 250 kg. of iron oxide ore. Together with the iron oxide that covers the scrap, the iron-ore serves as an oxidizing-agent. The smelting of the iron charge and the first batch of refining-slag requires from 4.5 to 5 hr. This slag becoming exhausted of iron oxide, and therefore of its oxidizing-power, samples are taken and tested to ascertain the degree of refining of the molten metal. According to the degree of purification, the furnace, after the first slag has been skimmed off, receives a second, and if necessary a third, batch of lime-iron oxides. After the removal of the last slag the surface of the metal bath is thoroughly cleansed by adding about 30 or 40 kg. of lime, which is later skimmed off. The further treatment of the iron bath depends upon the absence or presence of impurities which could not be removed by the lime-iron oxide refining and upon the quality of steel to be produced. According to these circumstances, new deoxidizing or otherwise-refining agents are employed; for instance, ferro-mangano-silicon, ferro-aluminum-silicon, ferro-mangano-aluminum-silicon, or other alloys. For producing carbon-steels, an addition is made of Swedish charcoal-iron, or an iron very rich in carbon, produced in an electric furnace at the steel-works.

After the refining-operation, the final step in the production of special steels is the addition of iron-alloys containing nickel, tungsten, chromium, or other special metals.

It is not the purpose of this paper to give a report on researches on the reactions during the refining-process; I shall have to leave this to the special sidero-metallurgists. I wish to



FIG. 9.—2.5-TON FURNACE AT UGINE.



Fig. 10.—2.5-Ton FURNACE AT SERAING, BELGIUM. SOCIÉTÉ JOHN COCKERILL.



Fig. 11.—12.5-Ton FURNACE AT UGINE DURING THE SMELTING-OPERATION.



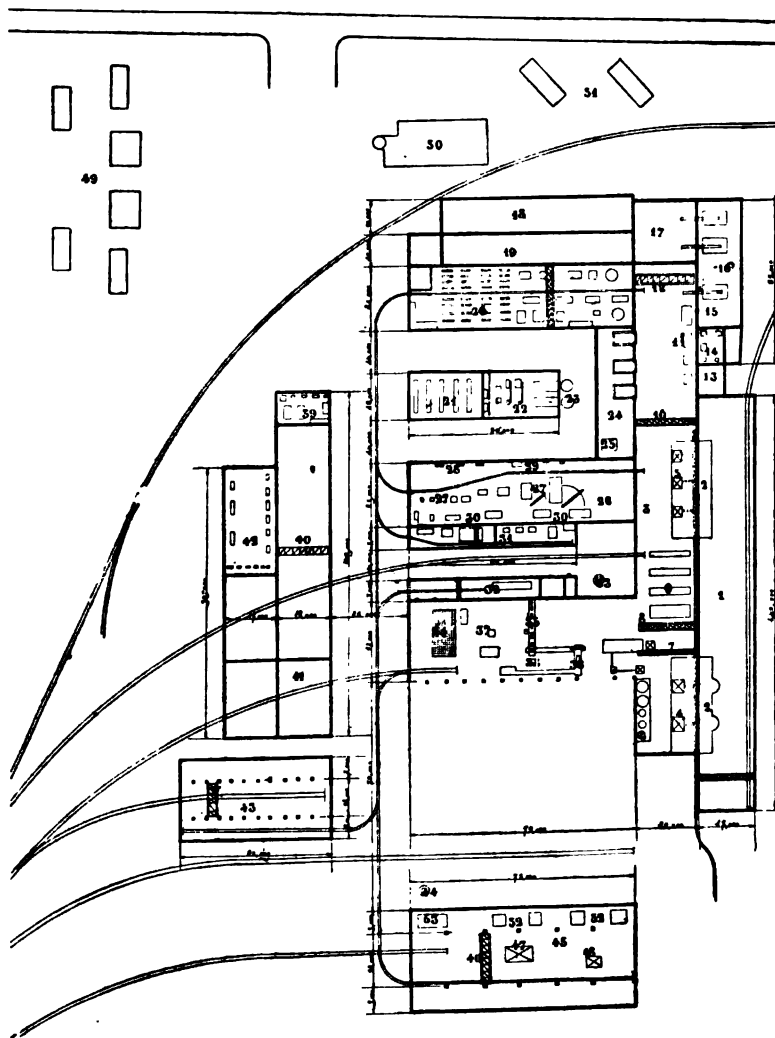
FIG. 10.—2.5-TON FURNACE AT SERAING, BELGIUM. SOCIÉTÉ JOHN COCKERILL.



Fig. 11.—12.5-Ton FURNACE AT UGINE DURING THE SMELTING-OPERATION.



FIG. 12.—12.5-TON FURNACE AT UGINÉ. FINISH.



- | | | |
|---------------------------------|--------------------------|------------------------------|
| 1. Store-house. | 19. Yard. | 37. Vertical shear. |
| 2. Furnace-platform. | 20. Machine-shop. | 38. 800-h.p. motor. |
| 3. Steel-works. | 21. Dressing-room. | 39. Testing-room. |
| 4. Furnaces. | 22. Power-house. | 40. 3-ton crane. |
| 5. Furnaces. | 23. Accumulator. | 41. Shipping-room. |
| 6. Ladle-heating room. | 24. Drying-furnace room. | 42. Pattern-shop. |
| 7. 10-ton crane. | 25. Compressor. | 43. Tempering-room. |
| 8. 4-ton crane. | 26. Forge. | 44. Chimney. |
| 9. Casting-pit. | 27. Hammers. | 45. Forge. |
| 10. 30-ton crane. | 28. Hammers. | 46. 60-ton crane. |
| 11. Molding-machines. | 29. Forge. | 47. 10-ton hammer. |
| 12. 4-ton crane. | 30. Heating-furnaces. | 48. Forging-press. |
| 13. Contact-tower. | 31. Annealing-furnaces. | 49. Laborers' village. |
| 14. Molding-room. | 32. Roll store-room. | 50. Offices. |
| 15. Cooling-room. | 33. Chimney. | 51. Dwelling-house. |
| 16. Chimney. | 34. Cooling-tables. | 52. Annealing-furnaces. |
| 17. Shop for cleaning castings. | 35. Finishing-mill. | 53. 600-h.p. air-compressor. |
| 18. Lathe-work shop. | 36. Rolling-mills. | |

FIG. 13.—STEEL-WORKS OF THE CIE. DES FORGES ET ACIÉRIES PAUL GIROD AT UGINE.

deal to-day with only the practical working of this useful electro-metallurgical apparatus.

The total duration of one smelting-operation, from the starting of the current to the casting of the products into ingots or molds, with raw material that is not pure, covers about 8 hr. With pure raw material less time and power will be required.

The smaller of the two types of furnaces used in steel-works is run with alternating currents of about 300 kw. at from 60 to 65 volts. The larger requires from 1,000 to 1,200 kw. at from 70 to 75 volts. Taking into account a loss of 10 or 11 per cent. of the charge by oxidation and evaporation, the power required to make 1 ton of steel in a small furnace is from 900 to 1,000 kw-hr., and from 800 to 900 kw-hr. in a large one.

The consumption of carbon electrodes amounts to from 12 to 15 kg. per ton of steel, including the short pieces which remain in the holders when the latter have reached the lowest point at which they can withstand the radiating heat of the bath.

The lining of the furnace, consisting mostly of calcined dolomite, will withstand at least 80 charges; but cavities eaten into the side-walls by the slag around the level of the molten bath are repaired with calcined dolomite at shorter intervals of time. The bottom of the furnace will stand from 120 to 160 charges without repair. The corrosion of the bottom during this time is about 100 mm.

Furnace-linings will stand a much longer time if liquid charges are used. One of these furnaces has run 200 charges without any repair.

The linings of the furnace-covers require more frequent renewing: in the small furnaces, after running 25 or 30 charges, and in the larger furnaces, after 20 or 25 charges.

The other parts of the furnace outfit are not worn out as fast as the linings and electrodes; the furnaces which so far have been put into operation still have their original outfits.

At the works at Ugine, scrap-iron is the only raw material used for steel-making as well as for the manufacture of iron-alloys. The larger part of the scrap is soft iron and steel, the smaller part pig- and cast-iron. The average percentage of impurities in the raw material used during a long period of operations was:

	Per Cent.
C,	0.400 to 0.500
Si,	0.150 to 0.250
Mn,	0.500 to 0.700
S,	0.060 to 0.090
P,	0.080 to 0.100

The degree of refining which can be reached in the Girod furnace is shown in Table I.

TABLE I.—*Analyses of Various Steel-Works Products.*

No.	Properties.	C.	Si.	Mn.	S.	P.	Other Con- stituents.
		Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1.	Very soft.....	0.079	0.106	0.205	0.015	0.012	.....
2.	Soft.....	0.236	0.180	0.431	0.012	0.010	.....
3.	Middle soft.....	0.283	0.208	0.430	0.014	0.010	.....
4.	Middle hard.....	0.388	0.155	0.342	0.011	0.009	.....
5.	Middle hard.....	0.463	0.204	0.463	0.010	0.016	.....
6.	Hard.....	0.596	0.198	0.302	0.017	0.005	.....
7.	2 per cent. of nickel.....	0.076	0.099	0.101	0.014	0.010	2.12 Ni
8.	3 per cent. of nickel, soft...	0.060	0.123	0.209	0.013	0.007	3.47 Ni
9.	3 per cent. of nickel, hard..	0.364	0.144	0.435	0.012	0.015	3.41 Ni
10.	5 per cent. of nickel, soft...	0.134	0.148	0.375	0.016	0.013	5.25 Ni
11.	5 per cent. of nickel, middle soft.....	0.250	0.157	0.414	0.010	0.015	5.08 Ni
12.	Nickel-chrome.....	0.420	0.199	0.500	0.010	0.009	{ 2.53 Ni 0.77 Cr
13.	Tool-steel.....	1.223	0.168	0.224	0.011	0.010	.....
14.	Tool-steel.....	1.474	0.119	0.264	0.015	0.007	.....
15.	Tool-steel.....	1.010	0.219	0.306	0.008	0.009	0.32 Cr
16.	Tool-steel.....	1.277	0.230	0.130	0.009	0.006	0.24 Cr
17.	Tool-steel.....	1.251	0.176	0.258	0.010	0.008	{ 1.21 Cr 0.49 Ni
18.	Tool-steel.....	0.689	0.029	0.096	0.012	0.009	{ 6.07 Cr 0.46 Mo 25.82 W

The cost of the different types of Girod furnaces and of complete plants is as follows:

A 2.5-ton furnace, including regulators for the electrodes, measuring-instruments, tilting-device mechanism, and conductors from the furnace to a dynamo, or transformer, near the furnace-room, costs about 15,000 francs.

A 12.5-ton furnace with a similar outfit costs about 30,000 francs.

The manufacturing-costs of the electrodes amount to 3 or 4 francs per ton of carbon body.

A complete plant, with one 2.5-ton furnace for regular running, and one furnace for reserve, with all appliances and smelter-building, but without dynamo or transformer, will cost approximately from 200,000 to 300,000 francs.

A plant equipped with a 12.5-ton furnace will cost from 300,000 to 400,000 francs.

Several years ago the Société Anonyme Electrométallurgique Procédés Paul Girod, at Ugine, Savoie, France, was created to operate the Girod processes for making iron-alloys and steel. This company owns the Girod alloy-works, in which also the first experimental 2-ton steel-furnace was tried. The fact that to-day 19 furnaces with from 400 to 600 e.h.p. are in operation, and that 12 new furnaces of 1,200 e.h.p. each are being erected, shows the extent of this manufacture. In the future these old works will be limited to making alloys only, and the old steel-furnace will be transferred to the new steel-works.

This company owns also an electrode factory with the most perfect and modern machinery, of a capacity of from 10 to 12 tons of electrode-carbons, round or square in cross-section, of diameters up to 350 mm., and in lengths up to 1,600 mm. At present only 7 tons are made, for which one furnace is used; a second furnace will be built as soon as the demand for electrodes increases.

The raw materials for the electrodes are retort-graphite, petroleum-coke, anthracite coal, and anhydrous tar. The solid materials are ground in ball-mills, kneaded with tar in double-screw mixers and in Chilean mills. The scarcely plastic mixture is now stamped into big blocks, which finally are pressed into blocks of the dimensions given above. These blocks are burned in gas-fired ring-furnaces, in the chambers of which are large fire-clay tubes containing the pressed blocks under a covering of ground coal.

The company owns several water-powers. The plant built for the old works is situated about 3 km. above Ugine, on the Arly river. Here a strong dam with gates sends the water into a tunnel, which leads it to a pipe-line directly above the power-house at Ugine. Ten Pelton-wheel turbines drive as

many directly-coupled dynamos, which furnish a total of from 8,000 to 9,000 e.h.p. The second power-station, furnishing an additional 12,000 e.h.p., is situated above Le Fayet. The tunnel and pipe-lines are large enough to carry the water for 20,000 e.h.p., but the power-house is equipped with turbines and dynamos for only 12,000 e.h.p. It will soon be enlarged. The three-phase current is sent under 45,000 volts to Ugine, where it arrives with from 40,000 to 42,000 volts. It is transformed here into currents of 2,500 volts for the large machines, and of from 60 to 75 volts for the furnaces. The 2,500-volt current is transformed into a current of 500 volts, and this into 110-volts for light and small motors, and a 500-volt direct current for locomotives, cranes, and similar uses.

In addition to this power the company leases from a power-station at Bionnay, upon the Bonnant river, near St. Gervais, 6,000 e.h.p., and from the Société d'Electrométallurgie Sud-Est at Veuthon, near Albertville, during the period October 1 to April 1, from 8,000 to 10,000 e.h.p. From both stations the current is furnished under an e.m.f. of 45,000 volts. The current from St. Gervais is conducted to Le Fayet, where it enters the Le Fayet-Ugine line.

For the production and the first mechanical and thermal treatment of the special steels, a new company, the Compagnie des Forges et Aciéries Electriques Paul Girod, also under the management of Paul Girod, has been formed. The works of this company have been built about 1 km. below the old works, and the electric current is supplied by the old company.

The installation which has been provided for the new steel-works, most of which is now in running order, is the following: Three 2-ton electric furnaces, one of which is used for small steel castings, and two 10- to 12-ton electric furnaces. The steel produced in these furnaces, except the one mentioned, is cast by means of large ladles, worked by electric cranes, into ingots, which go to the rolling-mills. Working with several furnaces for steel castings, pieces (dynamo-frames) up to 20,000 kg. have been made.

For the mechanical and thermal treatment of the steel ingots, the best modern machinery has been erected.

The rolling-mill has 2 three-high rolls, one of which can roll ingots of 525 mm. diameter and 400 kg. weight to rods of

125 mm. diameter. The other rolls ingots of 325 mm. diameter to smaller round, square, and other shaped rods. This mill has two furnaces for heating the ingots before passing to rolls, and the necessary cutting- and sawing-machinery for the rolled shapes.

A large forging shop contains 9 hammers operated by compressed air. The largest of these hammers weighs 5,000 kg.; the weights of the other 8 hammers vary from 1,000 to 100 kg. Here specially rough forgings are made, primarily for automobile machinery, shaftings, gears, tool-steel rods, projectiles, etc.

In addition to several annealing-furnaces already in operation, a large shop is being built for tempering, annealing, and hardening large forged or cast-steel pieces.

A second forging shop, now being erected, is to be equipped with one 1,000-ton forging-press, one forging-hammer of 10-tons hammer-weight, and three stamps with falling hammers, weighing respectively 3,000 kg., 2,000 kg., and 1,000 kg.

The steel-foundry contains a carpenter-shop for making patterns, a sand-separating plant, molding-machines, molding-frames, drying- and heating-furnaces, and a sand-blast jet for cleaning the finished castings. The foundry, with its present equipment, will be able to produce about 10 tons of steel castings daily, but, as mentioned above, pieces weighing up to 20,000 kg. may be cast.

A machine-shop now nearly completed has 6 drills, 5 lathes, 2 planers, and 1 grinder. Each machine is operated by a special motor.

The power-house is equipped with two transformers, two commutators, and four air-compressors, one of 30 h.p., one of 40 h.p., and two of 400 h.p. capacity.

The analytical laboratory, situated in the old works, is doing the investigations for both companies, and employs 15 chemists and assistants.

The new plant has a laboratory for making mechanical and physical tests of the products, which is equipped with all appliances to determine the mechanical strength and to investigate the microstructure as changed by mechanical and heat-treatment.

The two companies are erecting sanitary and comfortable dwelling-houses for the workmen and other employees.

I have been informed that in addition to the two Girod companies mentioned above, the following firms have ordered Girod furnaces, some of which have been operated for some time :

Oehler & Cie., steel-foundry in Aarau, Switzerland.

Société John Cockerill, iron- and steel-works in Seraing, Belgium.

Stotz & Co., steel-foundry in Kornwestheim, near Stuttgart, Germany.

Stahlwerk Becker, Krefeld, Germany.

Gutehoffnungshütte (one of the largest and oldest coal-mining, iron- and steel-smelting works in Germany), in Oberhausen.

Ternitzer Stahlwerk, Schoeller, in Ternitz, Austria.

Danner & Co., steel-works in Judenburg, Austria.

Ungarisches Staats-Stahlwerk in Diosgyor, Hungary.

From the above it is evident that at last the Girod furnace is earning the attention and success it so well deserves.

Glass Mine-Models.

BY EDMUND D. NORTH, TONOPAH, NEV.

(Spokane Meeting, September, 1909.)

IN making a glass model of mine-workings, each mine will present some little individualities, to meet which will call for the exercise of special ingenuity. Having made several models, I offer the following details of the model of the Montana-Tonopah mine-workings, believing that with small changes for different conditions the method described can be successfully used in making a glass model of the workings of any mine.

The model, Fig. 1, has the top, one end, and the front removed. The case is made of kiln-dried pine, painted with several coats of dead-white paint. It is made to take sheets of glass 24 by 42 in. in size, and is 18 in. high, the workings shown being on a scale of 1 in. = 40 ft., or 4800 : 1 scale.

The base is made of four pieces of 2-in. material, well pinned and glued together. The back, of material 1 in. thick, is secured rigidly to the base by screws and countersinking.

The four posts, 1.5 in. square, are so cut that the front and two ends of the model fit in flush with the outside edges of the posts. The top rails, 1 in. square, are fastened rigidly to the front and back posts by means of small iron braces.

The ends, front, and top of the case are of 0.5-in. material; the ends and front are held in place at the bottom by pegs fitting into the base; at the top the ends are held by buttons and the front by cupboard-hooks on the inside. Hinged hasps on the cover, fitting over staples in the end-pieces, make it easy to lock the entire case.

Before the back is fastened to the base, it is cut with horizontal and vertical grooves to receive the horizontal and vertical sheets of glass, shown clearly in Figs. 1 and 2. The horizontal grooves, spaced to scale, represent the vertical distances between the levels at the shaft. The vertical grooves are placed wherever cross-sections of the workings are desired.

The posts have horizontal grooves to correspond with those in the back. Strips of galvanized iron, 0.5 in. wide, and bent throughout their entire length so as to have two 0.25-in. faces at right angles, are fastened by small screws to the front and back posts, the upper surface of the iron being flush with the bottom of the horizontal grooves. This construction is very rigid, and the view through the ends of the model is not materially obstructed. Without these iron strips the horizontal sheets of glass do not have the proper end support, and tend to crack at the corners.

Eight 1-c.p. electric lights (frosted), placed in the base, make it possible to see clearly every part of the model.

The horizontal sheets, of ordinary double-thick glass, selected as free from bubbles and imperfections as possible, are 24 by 42 in. in size. The cross-sections are made on ordinary single-thick glass, cut 24 in. long, and in widths to fit closely between the respective horizontal sheets. These vertical strips are used, in places, from the base of model to the top, even when not used for sections, because of the support they offer to the horizontal sheets.

Fig. 3 shows the means devised to keep the vertical sheets of glass from moving laterally on the horizontal sheets at the front of model. These little clips are made of brass spring-wire, and as the thickness of the glass varies, they can be made to hold firmly anywhere. They offer very little obstruction to the view.

As the first mine-level is 400 ft. below the shaft-collar, because of a capping of about 370 ft. of barren andesite, the model shown in Figs. 2 and 3 starts at about 350 ft. below the collar. The lowest horizontal sheet in the model has the co-ordinates and claim-lines on it, this one sheet serving to orient the observer for all levels.

In case the model represents the mine up to the surface, a top sheet, showing the topography and surface-improvements, is often desirable.

If ground glass be used in place of clear glass for the bottom sheet, it will do away with reflection from the lamps, which may be noticed at some angles if clear glass is used.

A model as above described can be opened in a moment, and a clear view can be obtained—from either end through the

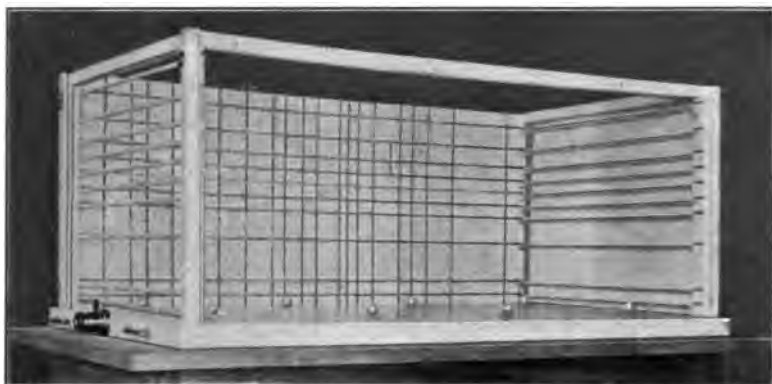


FIG. 1.—CASE WITH TOP, FRONT, AND ONE END REMOVED.

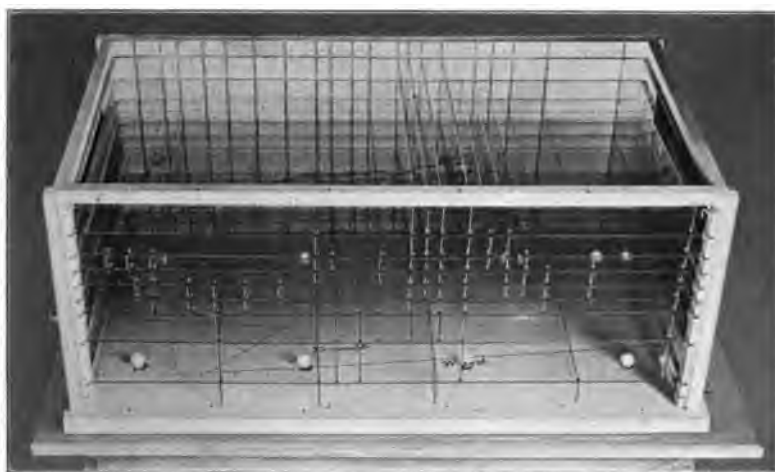


FIG. 2.—MODEL OF MONTANA-TONOPAH MINE-WORKINGS.

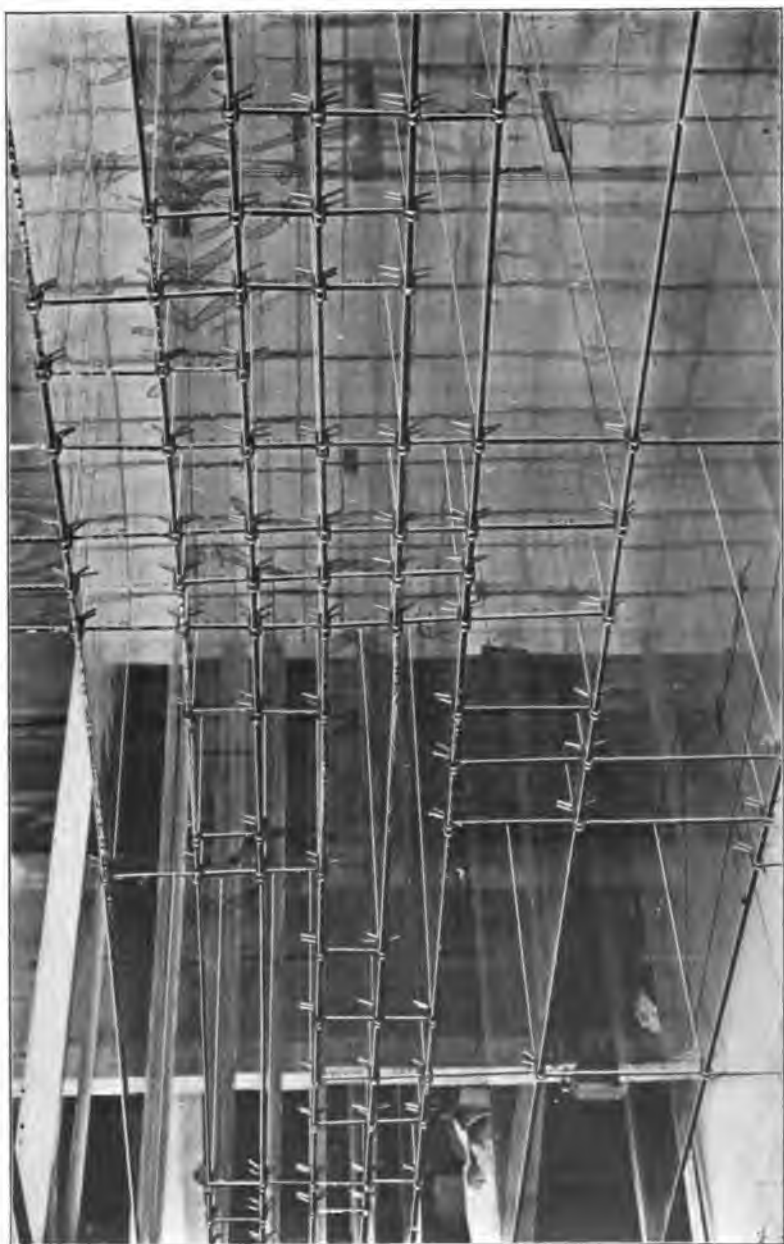


FIG. 3.—VIEW SHOWING WIRE CLIPS TO PREVENT LATERAL MOVEMENT OF THE GLASS SHEETS.

sections, from the top looking at the plans, or through the top at an angle, observing the plans and sections at once.

All the work is first platted on paper, and the glass plate is used the same as a tracing cloth would be.

Winsor & Newton oil-colors are used for drawing on the glass; an equal mixture of turpentine and white japan is made up in stock, and this is thoroughly mixed with the oil-color in a small dish as needed. Different colors require different amounts of this mixture added to them, the proper mixture for each color being obtained when it will flow freely from a ruling-pen to the glass and still be thick enough to stand permanently on the glass and not spread.

Free-hand lines and lettering can best be made with a ruling-pen, since on a glass surface this pen makes even lines in all directions. About 24 hr. is required for the mixture to dry; the levels can then be filled with their respective colors with a brush. It is best to have the outlines of the same color as that with which they are to be filled.

All sections being numbered, it is a simple matter to take the model apart and to put it together again, so that the work can be added to regularly and the model posted to date; new grooves can be cut in the back and new sections added wherever desired.

The sections in this model are north and south, and in any model it is well so to orient the work that the desired sections will be at right angles to the back of model. All workings which are at or within 10 ft. of a section are put on the section in full black; if desirable to show anything further away than 10 ft., it is dotted, showing it to be projected. By using care in choosing the sections, very little projecting will be found necessary.

The colors used for the levels are the same as those used on the working-map of the property—namely: first level, carmine; second level, blue; third level, yellow; fourth level, green; fifth level, purple; and intermediate levels, gray.

In sections, all work in ore is outlined in red; if desirable, the geology can be placed on each level and on each section by cross-hatching the different formations in different colors, which will show plainly the different formations without obstructing the view.

The Nicola Valley Coal-Field, British Columbia.

BY MILNOR ROBERTS, * SEATTLE, WASH.

(Spokane Meeting, September, 1909.)

THE Nicola Valley coal-field is small, but it seems likely to become important because of its commanding position in a rich region that is developing rapidly. Bituminous coking coal in workable quantity has not been found at any other point between the Crow's Nest Pass region, about 400 miles to the east, and Vancouver island, 250 miles westward. The Canadian Pacific railway reached the Nicola valley two years ago; two other lines, the Canadian Northern and the Great Northern, are building towards the valley. The vast region between the Rocky mountains and the Pacific coast, extending northward for several hundred miles from the international boundary, which has been the scene of extensive mining- and smelting-operations for many years, is filling up with settlers, who are attracted by the wealth of minerals and timber, the rich soil of the valleys, and the fine climate.

The Nicola river, flowing westward through the valley of that name in the Yale district, discharges into the Thompson river, which is the eastern branch of the Fraser. The trans-continental line of the Canadian Pacific railway crosses the mouth of the Nicola river at Spence's bridge, 178 miles from Vancouver. From Spence's bridge the Nicola branch line ascends the valley for 40 miles to Merritt, the coal-center, and continues 7 miles farther to the town of Nicola. Thus the haul from the mines at an elevation of 2,000 ft. to salt water is 218 miles down river grades. The Nicola branch will be continued about 150 miles farther eastward to Penticton, where it will connect with an extension of the line through the rich Kootenay and Boundary districts. The Canadian government has granted a subsidy of \$6,000 per mile, to which the pro-

* Dean, School of Mines, University of Washington.

vincial government is planning to add \$5,000 per mile, to assist in the construction of the Nicola extension. Upon the completion of this connecting link the Canadian Pacific railway will have a short southern route from the coast to its main line at Dunmore, Saskatchewan.

The Victoria, Vancouver & Eastern railroad is building a line up the Similkameen River valley from the Boundary region towards the Nicola valley. Rails are laid and trains are running to Keremeos, while grading has advanced to Princeton, 60 miles from Merritt. This road, which has connections with the Great Northern railroad at Spokane, Wash., will give the Hill lines a direct entry into Vancouver from the east. The route as surveyed passes near the Nicola field, and a connection there is a practical certainty.

Construction of the Canadian Northern railroad has advanced as far westward as Edmonton, Alberta. The line of its location-survey extends from Edmonton across the Rocky mountains through the Yellowhead pass and turns southwest to the Thompson river. It passes either through the Nicola valley or not far from it, and continues down the Fraser to the western terminus at Vancouver. A general election, called for Nov. 25, 1909, will decide the questions of the route to be allowed the Canadian Northern, and the amount and form of government assistance to be granted it.

The Grand Trunk Pacific, Canada's third transcontinental road, with terminus at Prince Rupert, crosses British Columbia several hundred miles north of Nicola valley. A survey is now being run for a branch line from the main line in the neighborhood of Edmonton to Vancouver, passing through the Nicola valley.

The Nicola coal-field lies wholly in the valleys of the Nicola and Coldwater rivers, which unite at Merritt. The area known to be underlain by coal is about 8 miles long by 4 miles in greatest width. The Quilchena field, lying 8 miles farther east, is similar in many respects, but is not developed. A deposit of fine alluvium covers the floor of Nicola valley and forms a deep rich soil at the surface. The coal-measures lie directly beneath it, and outcrop through the alluvium at only a few points on the edges of the valley. From the present workings and the outcrops it appears that the measures form mainly a

synclinal trough surrounded by igneous rocks. Near the contact with the latter, at certain places, the sedimentaries are irregular in dip and strike, perhaps showing lesser folds, but the variations seem to be simple and do not interfere with development or mining.

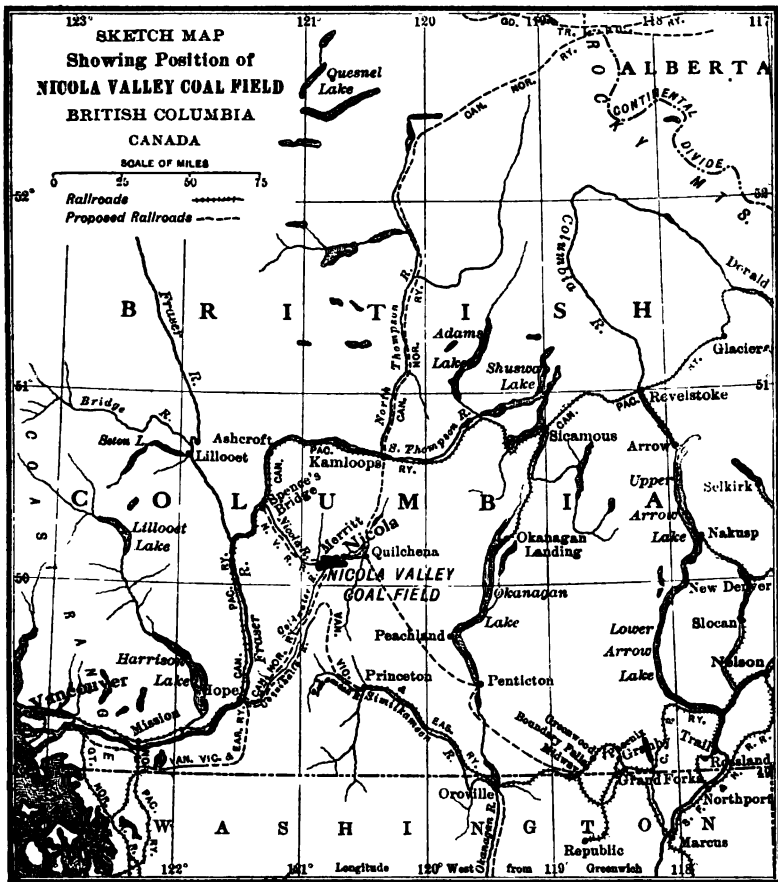


FIG. 1.—SKETCH-MAP OF A PORTION OF BRITISH COLUMBIA, SHOWING THE NICOLA VALLEY COAL-FIELD.

The coal-measures, which Dr. Dawson and Dr. Ellis, of the Canadian Geological Survey, term the Coldwater group, seem to have been deposited in the very early part of the Tertiary, wholly previous to the extensive volcanic activity that occurred in Miocene times and produced the present walls of the valley.

At the base of the Coldwater group, where coal is lacking, conglomerate-beds appear; higher up in the series the rocks are mostly alternating sandstones and shales with numerous beds of coal. The workings are not extensive enough to allow a complete correlation of the measures in different parts of the field, but it is probable that there are at least eight or ten workable seams more than 3 ft. thick.

The first mining of any importance was done near Coal Gully, in the southern part of the field, in December, 1906, by the Nicola Valley Coal & Coke Co. This company has opened up considerable ground and is now putting out about 300 tons per day, which is sold mostly to the Canadian Pacific railway. The Diamond Vale Coal & Iron Mines, Ltd., have carried on development near the center of the valley, on both slopes of the syncline, by means of diamond-drill holes, shafts, and slopes. Approximately 6,000 tons of coal have been produced, but present efforts are being confined to development. The Coal Hill Syndicate recently opened two valuable seams, of which one is 10.5 ft. thick. Incidentally, the latter work has extended the known area of the coal-field west of Coal Gully, the place of original discovery. Diamond-drilling, now being carried on by the Nicola Development Co., Ltd., in which I am interested, is proving that the northern portion of the field is valuable, and is of greater extent than any of the maps have shown.

Room-and-pillar is the usual mining-system. The Nicola Valley Coal & Coke Co. mined, perhaps, two or three thousand tons by long-wall, but the experiment did not prove wholly successful. The same company is installing a compressor and 10 Siskol coal-cutting machines to be used in both narrow work and rooms. The thickest seam developed anywhere in the field at this time is the Nicola Valley, No. 1, which measures 18.5 ft. from floor to roof, including a 2-ft. parting of hard clay. The floor of the seams in general is sandstone, less often hard shale. Less than half the present gangways and slopes are timbered, owing to a dependable roof, which is mainly fine-grained sandstone, sometimes with "following stone" of "slate" from 4 to 8 in. thick. In most places the seams are solid enough to yield a very good proportion of lump in the run-of-mine coal. Dips are encountered as low as 10°

and as high as 40°; the usual limits, however, appear to be 15° and 30°. The amount of "gravity" coal in the valley is quite limited. All the workings are dry, except in a few places where the water evidently penetrates from the surface. Traces of gas have been detected in the past at certain points; recently it has become quite noticeable in one of the pits.

All of the mining- and parts of the hauling- and loading-work are done by contract. For seams less than 5 ft. thick the contract-price of coal on the cars is \$1 per ton, while for thicker seams 80 cents is paid. Underground laborers receive average wages of \$3 for an 8-hr. day; outside men, \$2.75 for 9 hr. Posts and caps of yellow pine from the surrounding hills cost 5 cents per foot. Stulls of cottonwood from the river-bottoms cost 10 cents each.

Nicola Valley coal is bituminous in character, and yields an excellent coke for copper-furnace and blacksmith purposes. The composition varies somewhat in the different seams, but in a given seam it appears to be constant. The moisture is unusually low for a Western coal, running from 2 to 7 per cent. The volatile constituents vary from 32 to 39 per cent., and the fixed carbon from 49 to 57 per cent. The amount of ash in the coal when it reaches market can be kept within a reasonable limit, say from 4 to 8 per cent. Although some of the seams contain bone or shale, which is either sorted out by the miners or picked out at the tipple, the coal itself is clean. In the mining- and handling-operations fine dirt accumulates in the coal, particularly with the small sizes, but the latter respond readily to jigging-tests, and yield products low in ash. Sulphur, in the form of pyrite, varies from 0.5 to 1 per cent. A large lump of Diamond Vale coal, which had been exposed to the air for some time, gave the following analysis:

	Per Cent.
Moisture,	2.66
Volatile constituents,	37.84
Fixed carbon,	55.14
Ash,	4.36
Total,	100.00

Markets for Nicola Valley coal and coke are near at hand. The three railroads already mentioned will have long stretches of road, from 300 to 400 miles each, in which Nicola will have

the advantage of short haul in comparison with other fields. In addition to the main lines, branches are certain to be built soon through the nearby mining and agricultural districts of British Columbia and Washington. The mining and smelting industries of southeastern British Columbia, which are increasing in importance, now obtain their coal and coke from distant points at high cost. Lastly, the demand for coal to be used for domestic supply and for power purposes is growing steadily. Although stock-raising and lumbering will continue to be important industries in the region, agriculture and horticulture have gained firm footholds. Many of the valleys, including the Nicola itself, have been found capable of producing under irrigation abundant crops of the finest grades of apples and other fruits. With the influx of country settlers, naturally the cities and towns are thriving. In general, southern British Columbia is keeping pace with the rapid development of the Pacific Northwestern States.

An Adjustable Pyrometer-Stand.

BY L. W. BAHNEY,* PALO ALTO, CAL.

(Spokane Meeting, September, 1909.)

FREQUENTLY in using a thermo-electric pyrometer for measuring the temperature of a furnace, a hole is drilled at the back or side of the furnace, through which is introduced the tube containing the thermo-couple. At times the couple is left almost where it drops, for the reason that it soon becomes too hot to be handled easily, and the space at the back or side of the furnace may be so small and uncomfortably hot that an easy and accurate adjustment is nearly impossible. In order to overcome this clumsy and unscientific method of using the thermo-electric pyrometer, I designed an adjustable stand, to hold the clay or quartz tube inclosing the platinum and platinum-rhodium leads that constitute the couple of the Le Chatelier thermo-electric pyrometer. This stand also allows an easy and rapid adjustment of position to varying heights and angles, as may be desired for special reading.

This stand is illustrated in Fig. 1. The couple in the tube might be of better service if the tube were held a little higher above the charge in a roasting-dish, changing the height and angle if desired.

The stand, made of 1.5-in. water-pipe and mounted on casters, is heavy enough so it cannot be tipped over easily. It is adjusted to any position, and has a universal clamp which holds the clay or quartz protecting-tube.

To avoid disturbing the wires of the couple at the cold junction each time the tube is moved, the cooling-bottle sets in a wire basket so placed that it moves forward or back with the couple.

To overcome the necessity of leveling and adjusting a galvanometer at each furnace, a switch-board is used to connect

* Instructor in Metallurgy, Stanford University.

the pyrometer with the galvanometer by means of three binding-posts placed at each furnace.

The furnaces are numbered from 1 to 12, and to facilitate the work two galvanometers are used, *A* and *B* in Figs. 2 and 3.

On a block in front of each of the furnaces, Fig. 3, are binding-posts *A* and *B*, to correspond to the galvanometers, while the central post is numbered according to the furnace. Thus, the binding-post block of furnace No. 3 would be marked *A 3 B*.

The connection between the binding-posts and the switch-board is by means of a telephone cable cased in a lead tube. Beneath the furnace this tube is inclosed in a conduit for protection.

The switch-board is of marble, having a plug for each of the galvanometers, *A* and *B*, and 12 holes, each bearing the number of a furnace, so that any individual furnace may be connected with either galvanometer, or with both.

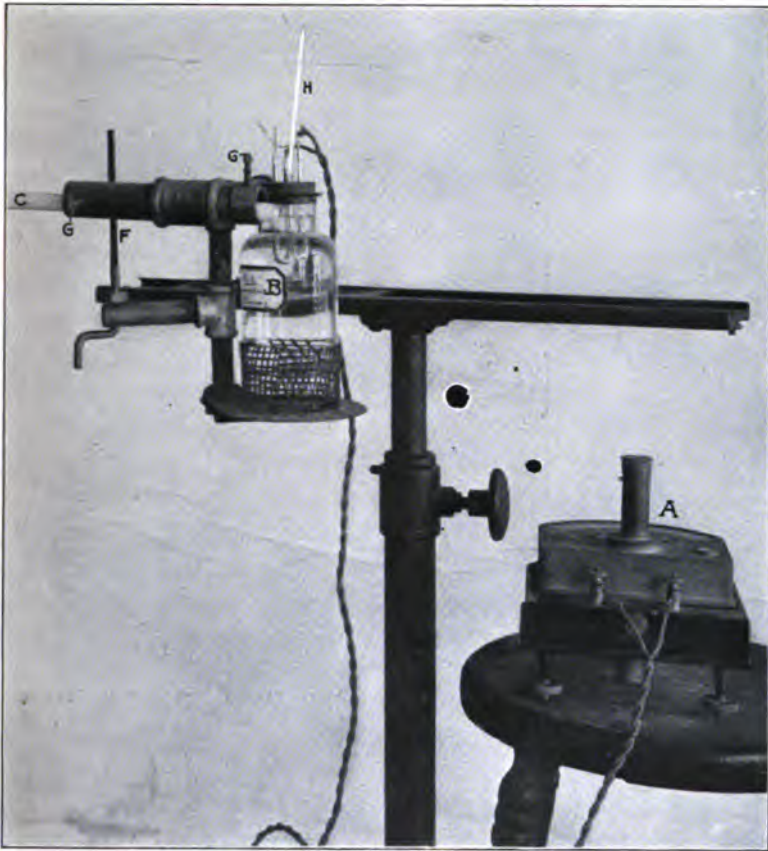
A perfect adjustment of the galvanometers is obtained by placing them in a dust-proof case mounted on a concrete pillar, 1 by 2 ft. by 4 ft. high, resting in sand about 1 ft. below the floor, as shown in Fig. 3.

The wooden base, which merely covers the hole in the floor at the front, back, and sides, is fastened to the pillar, so that any motion of the floor is not communicated to the galvanometers.

In calibrating the couples, the readings of the galvanometer are taken through the cable and switch-board, so that similar conditions will obtain when in use.

For general work, the Battersea clay tubes made by the Morgan Crucible Co., England, are the best, as they are not so easily corroded and broken as are the quartz tubes.

In one instance the quartz tubes available for my use were 0.5-in. bore and about 3 ft. long. Wishing to use a couple longer than 3 ft., I took the quartz tube and placed next to it an 18-in. Battersea clay tube of the same bore, closed at one end, then slipped a piece of porcelain combustion-tubing, 1-in. bore, over the joint, and poured the space between the combustion tubing and the quartz and clay tubes full of a thin plaster-of-paris paste.



- A.* Siemens-Halske galvanometer.
B. Cold junction filled with water, containing small U-tubes filled with mercury, by which the contact is made with the couple-wires and the lead to the galvanometer.
C. Quartz protecting-tube, 0.5 in. bore.
F. Fine-adjustment screw.
G. Thumb-screws for fastening the protecting-tube.
H. Thermometer.

FIG. 1.—VIEW OF ADJUSTABLE PYROMETER-STAND.

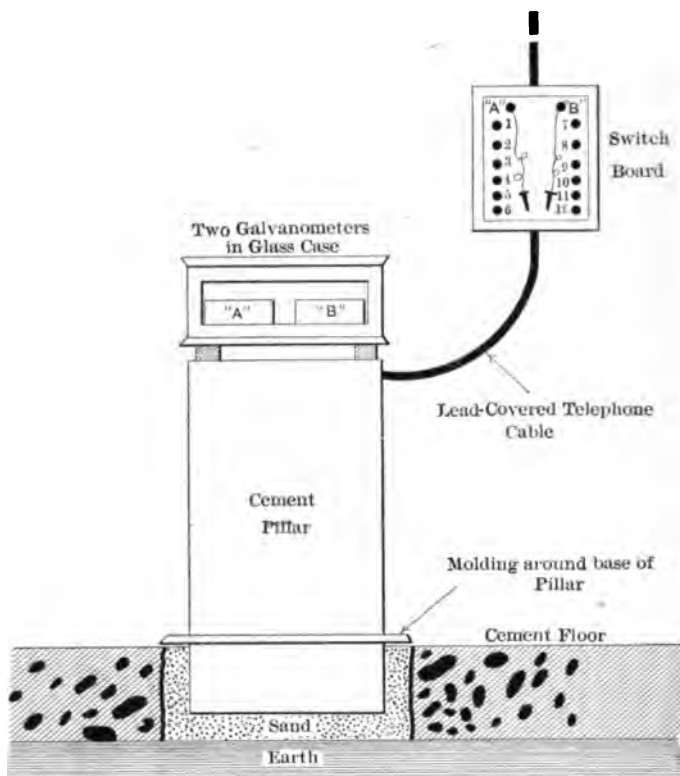


FIG. 2.—DETAILS OF CONSTRUCTION OF ADJUSTABLE PYROMETER-STAND.

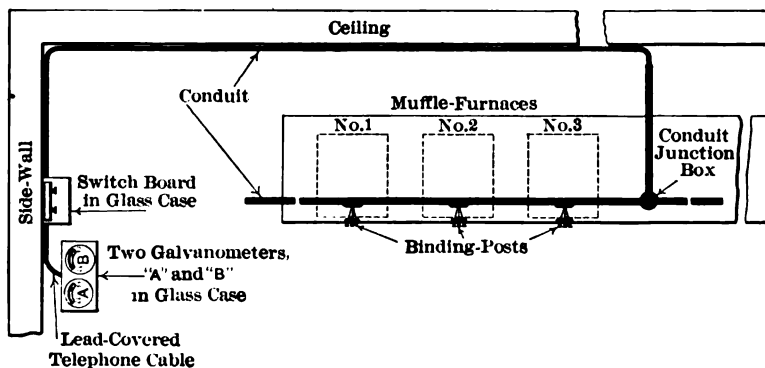


FIG. 3.—PLAN SHOWING ARRANGEMENT OF STAND AND FURNACES.

Cyaniding Slime.

BY MARK E. LAMB, MILWAUKEE, WIS.

(Spokane Meeting, September, 1909.)

THE various methods of treating pulp in air-agitation tanks offer problems for experiment and study which are fascinating as well as practical. The usual method heretofore has been to fill each tank in turn, agitate the mixture the required period and then discharge the treated pulp into a storage-tank, from which it is drawn to the filter as required.

A later method is to run the pulp from the tube-mill, classifier, thickener, or settler into the first of a set of tanks, and thence continuously or in series through the remaining tanks, finally drawing off the pulp to a continuous filter, or to a pulp-storage tank if the filter is of the intermittent type. It is this method which I propose to discuss here in a preliminary way, with the idea of going exhaustively into the examination of the results of a series of experiments in a later paper.

It may be of interest to note that the design of a cyanide-plant has recently been completed in which the estimated cost of the agitation-tanks, storage-tanks, and pumps was 30 per cent. higher for the charge-agitation arrangement than for the series plan.

The first question in studying the series method is, "What is the actual period of treatment undergone by the pulp?" One first supposes that by chance some of the pulp may get through with little or no treatment, while other portions may stay in the tanks a needlessly long period. The former is not probable or even possible, and the latter is, practically, true to only a limited extent. The greater the number of tanks the greater is the percentage of chance that all the pulp will be treated equally. Without going into the mathematical analysis of the problem (which is of little value, since it is based on problematical premises), its important terms may be clearly grasped by thinking of, or "visualizing," the conditions when,

say, 50 tons of dry slime is treated in 24 hr. The thickened pulp representing this tonnage is a sluggish, 2-in. stream flowing 25 in. per second. Taking the flow of this stream for any given period, say 5 min., 16 cu. ft. will flow into the first of a set of agitation-tanks. If the tanks have a working-capacity of 1,600 cu. ft., one such tank will contain 17 tons (dry weight) of slime in a 2-to-1 pulp, and three tanks will be required to agitate 50 tons for 24 hr. Assuming an instantaneous mixture of the stream of incoming pulp with that already in the tank (an impossible condition which will be discussed later), then 1 per cent. of 16 cu. ft. will be discharged with no treatment. With two tanks the proportion which would be discharged with no treatment is reduced to 0.01 per cent. Of course, other portions would be discharged with varying and increasing periods of treatment.

The rate of flow of the pulp from the time it is thrown out of the top of the central tube until it reaches the bottom of the tank varies with the amount of air used and the shape and the size of the tank. The period is from 0.5 to 2 hr. If the incoming stream enters at the side of the tank opposite the outlet, and giving due consideration to this slow movement of the charge, it is a physical impossibility for any particle of the pulp to go through this series of three tanks in less than 1 hr. 30 min. In the mathematical analysis this minimum period gives the series method a big handicap, and one which increases directly with the number of tanks used. In fact, this low circulation-velocity makes the operation resemble the treatment of pulp in a horizontal tube of the same diameter as the agitation-tanks and of a length equal to the combined lengths, having the agitation at right angles instead of parallel to its length.

If any comparisons have been made on a practical scale to show the difference in extraction by the two methods of using the air-agitation tanks, the results, so far as I know, have not been published. Such a test would be of great interest, and the managers of several plants are now in a position to make it. In tests on a small scale, with tanks of a capacity of 100 lb. of dry slime in a 2-to-1 pulp, several interesting things have been noted. With pulp containing coarse sand (and even with fine sand in a thin pulp), care must be exercised in drawing the

pulp from one tank to the next in the series, otherwise either the sand or the slime will accumulate. If the drawing-off pipe is merely flanged to the tank, the outflowing pulp will contain a greater proportion of slime to sand than is contained in the average of the pulp, since during agitation by this method the sand has a tendency to sink through the pulp as soon as discharged through the central air-lift, rather than to work out to the sides of the tank with the flocculent slime. This difference in pulp-flow is greater with a thin mixture and less with a thick one, and can be utilized practically in a very simple manner if it is desired to agitate the sand longer than the slime. A concentration of sand in the tank will be attained by drawing the slime from a quiet point in the circumference of the surface of the pulp. To do this, a discharge-pipe, pivoted at the side of the tank, is arranged to swing in a horizontal plane and to be placed and held at any desired point in its arc between the central pipe and the side of the tank. After the desired initial concentration is attained, this discharge-pipe is then placed so as to draw off a mixture of the same proportions of sand and slime as that being fed to the tank, which will maintain the charge in the tank at the higher ratio of sand to slime. Thus the slime will go through faster and the sand slower than the average pulp-flow. To illustrate this point, imagine a tank containing 100 tons (dry weight) of pulp consisting of 3 of sand to 1 of slime. Admit a stream of pulp carrying 100 tons in 24 hr., which consists of half sand and half slime, drawing off an exactly similar stream. The slime which was originally in the tank (25 tons) will be replaced twice in 24 hr. by the 50 incoming tons, while the original sand (75 tons) will be replaced only two-thirds time. In other words, the slime will receive a 12-hr. treatment and the sand will receive a 36-hr. treatment. I consider this one of the important advantages of the "series" system. The regulation of the ratio of sand-concentration in the tanks, within the practical limits to be determined in each case, will be controlled by taking a pulp-sample of a certain size, washing it through a 200-mesh screen, and setting the discharge-pipe as many inches from the rim of the tank as there are ounces of sand remaining on the screen. The proper weight of the sample to give best results can be determined experimentally.

A point of great advantage possessed by the series method in the design of many plants is the saving in difference of level required in the site. The agitation-tanks, if used in this manner, need not require more than from 2 to 4 ft. difference in level between the inlet and the outlet, depending to some extent upon the number and size of tanks and the distance apart, but also and mainly upon the margin of capacity required to provide for fluctuations in pulp-feed and discharge. This margin depends largely upon the type of filter used. Ordinarily, the pulp will be drawn from near the top of the last tank, while in the "charge" system the outlet is at the bottom of the tank.

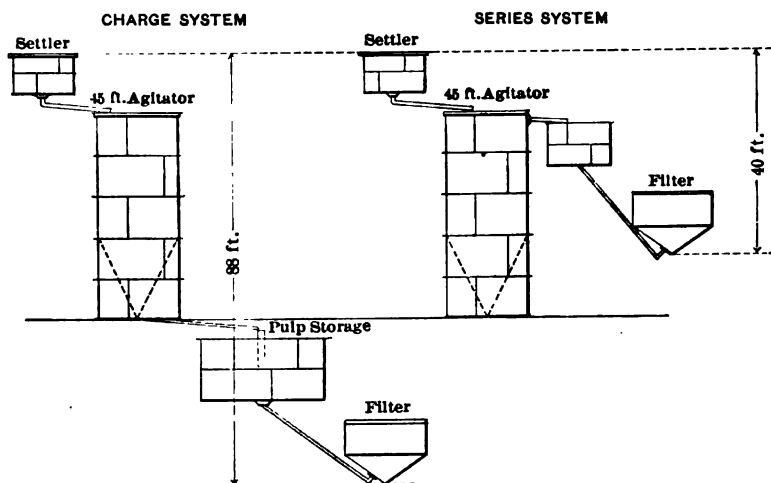
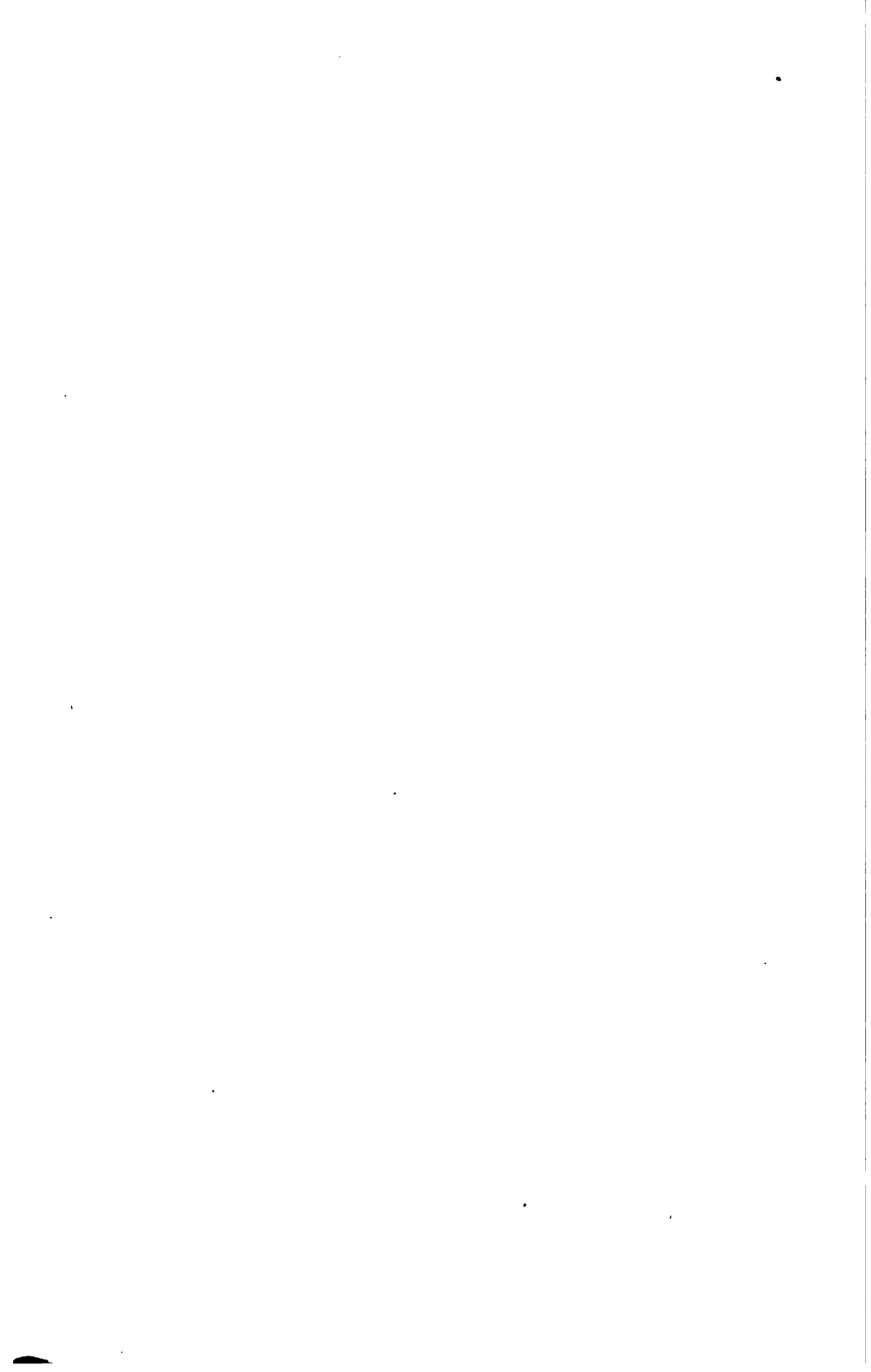


FIG. 1.—CHARGE SYSTEM AND SERIES SYSTEM COMPARED.

Fig. 1 shows this difference. In the series system no storage-tank is needed below the last agitator-tank if a continuous filter, such as the Oliver or the Ridgway, is used, only a small tank of a capacity to supply pulp to equal the displacement of a loaded basket of leaves if a Moore filter is used, and a slightly larger tank (sufficient to fill the filter-box with the unloaded frames in place) with a Butters filter. Compare this arrangement with the charge system, in which the storage-tank, even with continuous filters, must have at least a capacity equal to that of an agitator, and with either the Moore or the Butters filter must have a slightly greater capacity, as is explained above.

The question, What is the least number of tanks which can safely be used in this manner, can only be answered by experiments. Even with the charge system, the occasion will rarely arise in which it will be convenient to use less than two tanks for agitation, and in such a case three smaller tanks with equal average treatment-capacity will be so much smaller that their combined cost will be little, if any, more than the cost of the two larger tanks. In a plant having air-agitation operated on the charge system, it is rare that the site will permit all transfers of pulp—from settler through agitators and storage-tank to filter—by gravity. Usually the saving of about 45 ft., as shown in Fig. 1, will practically amount to the saving at least of the cost of a 4- or 6-in. steel-lined centrifugal pump, with its requirement of from 10 to 20 horse-power.

There are numerous plants at which a change to the series method of treatment could be made at slight expense, with an increased capacity and easier work for the plant-foreman. I have in mind a plant with at least twenty 12-ft. air-agitation tanks, each of which is used as a settler in its turn. This arrangement entails continual running by a shift-man and several helpers. The result of installing a Dorr continuous slime-thickener, together with connections between all these agitation-tanks, would be a revelation and a revolution.



Professional Ethics.

BY R. W. RAYMOND, NEW YORK, N. Y.

(Pittsburg Meeting, February, 1910.)

IN June, 1906, I delivered to the graduating class of Lehigh University an address upon this subject, the substance of which, with sundry omissions and additions, was subsequently repeated, in October of the same year, in an extempore address before the Schenectady branch of the American Institute of Electrical Engineers. The latter, as stenographically reported, was published in the *Proceedings* of that society for November, 1906, and was referred to by President John Hays Hammond in his address at the Chattanooga meeting of October, 1908. Requests have been received from various quarters for the republication of this address by the Institute. This I do not regard as necessary or proper; but I yield to that demand so far as to reproduce in the *Bulletin* a summary of my views, as expressed in the two addresses above mentioned.

I considered the subject of professional ethics under the several heads of the positions likely to be occupied by engineers—namely, as authors, employees, agents, or private or public advisers. Under these heads I said in substance:

1. *Authors.*—The author is party to an implied contract with his reader, in which he covenants that he has something to say, and will say it clearly, honestly, and fully. He ought, therefore, to avoid all obscurities or ambiguities of style; “mixed figures” of rhetoric (which are essentially insincere, because they present as seen by him pictures which could not possibly have been sanely seen by anybody—as when Wendell Phillips said the time would come when Liberty would “stand by every new-born child, and drop in its cradle the school-house and the ballot-box!”); misuse of quotation-marks, by making them include anything else than *verbatim* quotations; second-hand references to authorities not actually verified by the author, without specific statement of the fact, etc. And a technical author

ought, in good faith, to furnish his reader with all the aids to further detailed inquiry which he himself possesses. In other words, he is bound to give, not only his own conclusions, but also such a statement of his grounds and authorities as will fairly show the range of his own knowledge.

2. *Employees*.—Under this head, both duty and policy dictate a loyal devotion to the interest of the employer and a consideration of duties rather than rights. Even from a selfish stand-point, loyalty commands to-day the highest price in the market.

3. *Agents*.—The obligations of this relation are as clearly defined by law as by personal honor. No agent may have secret personal relations, affecting the interests of those for whom he is openly acting. The payment of commissions to purchasing agents is a case in point. Sometimes, by reason of trade-agreements, a manufacturer cannot sell to a customer below a certain price, yet is permitted to pay the agent who procures the customer for him. If that agent is at the same time the agent of the purchaser, he cannot honorably receive such a commission without the knowledge of his principal. But, if the rules of trade make this the only way of securing a reduction of price, he may accept such a commission and turn it over to his employer, in which case he should insist upon receiving it in a check to his order, and indorse the said check to the order of his employer, so that there may be no doubt in any quarter as to the disposition which he has made of it.

4. *Private Advisers*.—Under this head, perhaps the most frequent function is the writing of letters of recommendation. Do not give general letters of this kind if you can avoid it. A letter which the candidate carries in his own pocket, and of which the contents are known to him, has little weight the first time it is exhibited, and less and less weight as time goes on; and it becomes dog-eared and dirty through frequent presentation or pocket-wear. Moreover, a letter of personal recommendation is really a piece of advice to an unknown client; and it cannot possibly be made as clear and effective as it ought to be, if it is drawn in a general form, without knowledge of the particular requirements of the said unknown client. Even for the benefit of your best friend, it is much better to give a letter, authorizing him to use your name as a reference, and

promising to answer, confidentially and fully, any inquiry that may be made of you concerning him. Such an inquiry will come only from some party seriously considering the engagement of the candidate. When it does come, it can be answered with intelligence and freedom; and if the man is, in your opinion, a good man for the place, he will be ten times as likely to get it, upon such a statement from you, as upon the strength of your vague general recommendation, presented by himself. But in all such cases it should be remembered that the inquirer, not the candidate, is your client; and, even in giving the most favorable opinion, you should carefully state the extent of the knowledge upon which it is based. You have no right to try to get a place for a friend by misleading or incomplete advice to your client, his prospective employer.

Under the head of private advice falls the advice given to clients as to investments. Here honor requires, in the first place, that the client should not be deceived as to your ability to deal with his particular problem. The numerous instances in which scientific experts in one line have undertaken, with disastrous results, to give opinions in another line, furnish sufficient illustration of this proposition. There was a time when experts were scarce in this country, and a chemist was regarded as competent to pronounce judgment upon a piece of mining-ground. But the situation has been so changed that, nowadays, even a trained mining engineer cannot be trusted for such a judgment unless, in addition to his general knowledge, he has also a special acquaintance with the nature and history of the particular kind of mining and the particular district concerned. One of the most eminent mining experts within my acquaintance never undertakes to report upon an enterprise in a region not familiar to him without engaging, at his own expense, a local expert of his own selection, to post him as to such matters as his own examination might miss. (I note that Mr. Hammond approves this course.)

I can recall instances of really able and unquestionably honest mining experts who, lacking such local aid, and ignorant of local conditions and history, have reported hundreds of thousands of tons of ore, on the strength of scattered "float" from a comparatively small outcrop.

It is true, that a thoroughly trained mining engineer should

be able, by keen and faithful study, to get at all the essential facts for himself; but he ought to be frank with his client beforehand, and let the latter clearly understand the situation.

Private advice is also dependent upon the nature of the question presented. The client may say, "Here is the report of the owner of the property. I have agreed to buy it, if his statement be true; and I employ you to verify that statement." Such a commission is entirely honorable; yet the discharge of it is not altogether agreeable or safe for him who performs it. For the condition stated is narrow, and its honorable fulfillment is liable to serious subsequent misunderstanding. If, for instance, the expert should find that the representations of the vendor, which he was sent to verify, were true, but that other and equally promising mining-property in the neighborhood could be bought for a lower price, he could not properly include in his report any reference to that more profitable alternative. Yet his favorable report as to the vendor's statement submitted to him, might be construed afterwards as a recommendation of the purchase, which was not really submitted to him at all. This situation occurs, perhaps, most frequently under the English system of organization of mining companies, according to which a company is organized on the basis of a vendor's statement, for the purpose of purchasing a certain mining-property, provided that statement be indorsed as correct by a competent expert, selected to represent the company. Upon the report of that expert, the existence of the company itself, and all the profits of its promoters, depend; and it would be, of course, unprofessional for him to declare that, while the representations of the vendor were true, he had heard of another investment, which he thought was better!

For the mining expert himself, it is highly desirable to insist, if practicable, upon a wider authority, permitting him, not only to verify the vendor's report, but also to advise as to the purchase itself. Either duty, I think, may be honorably undertaken; but in the former case, the expert should take care that his task and responsibility are clearly expressed, especially if his report is likely to be published afterwards, and thus converted from private to public advice.

5. *Public Advisers.*—Under this head fall the expert reports which are published in the prospectuses of mining companies,

and the testimony of experts in court. Under the first head, I have only to say: (1) That an expert has the right to insist that his report should not be garbled, by fragmentary publication or otherwise, so as to support a scheme which it did not contemplate or approve; and (2) that his protest against such misuse of his statements should be made promptly. As I said to the Electrical Engineers, "Don't come limping in, after a scheme has failed, to protest that you never meant to approve it in all respects. Speak quick, or shut up!"

Among public advisers are those who appear as expert witnesses in court. The difference between an expert witness and an ordinary witness is, that the former is expected, while the latter is forbidden, to give his opinions, and to state, among the grounds of those opinions, the facts and conclusions reported by others, as well as those personally verified by himself. The expert's position is, that he has been called, as *amicus curiæ*—a disinterested "friend of the Court"—to assist judge and jury in the interpretation of the evidence, a part of which may be his own testimony as to facts observed by himself. But as to his statement, whether of such facts or of his opinions, the expert should not forget that he has sworn to state the truth fully and only. It has often been urged that experts should be employed by the Court, and not by either party. This plausible notion involves the selection of such expert advisers without knowledge of their theoretical views. I have had some experience of the practical working of that plan; and I can testify that it results in opinions, usually voluminous and vague, which need further expert interpretation before they can become useful guides to judge or jury. Moreover, the Court may innocently select an expert who is a partisan of a particular scientific theory. On the whole, therefore, I am thoroughly convinced that our present American system, under which expert witnesses are presented by each party, to be cross-examined by the other party, is, with all its inconveniences and costs, best adapted to elucidate the truth and promote the ends of justice. It must be confessed that, under that system, the expert witness becomes an advocate; for neither party in a law-suit would produce such a witness without knowing beforehand that his opinions were favorable to its contention. Yet it still remains true that the expert witness is, after all, a sworn adviser of the

Court. Under these circumstances, what is his professional duty?

I have answered this question by declaring:

a. That no expert can honorably serve in such a capacity, without having previously made sure, for himself and his clients, that he can honestly defend their contention.

b. That if, after having, on a preliminary retainer, studied the case, he cannot do this, he should decline to appear as a witness in court, either for that side or the other.

c. That his preliminary study of the case should be so thorough as to warrant him in propounding and defending in court his expert theory. He may fairly appear as a partisan of that theory, though not of the party aided by it. And, in defending his view, he is still under oath, and must not shrink from the candid acknowledgment of new evidence presented by the other side, not previously known to him, or deal with such evidence evasively or controversially, for the purpose of protecting his own reputation. He is justified in saying that he has made up his deliberate opinion upon all the facts observable or ascertainable by him, and cannot change it upon the presentation of new evidence which he has had no opportunity to test and weigh.

Above all, the expert witness should not try to be smart or witty under cross-examination. In such an encounter his hands are tied; for he is under oath, while the inquiries and insinuations of his antagonist are unrestrained.

The best expert witness I ever heard courteously assumed that the cross-examining attorney was sincerely in quest of information, and gave it to him with fraternal and pedagogical cordiality which simply paralyzed his attack! I have seen many a witness beat a lawyer in repartee, and lose the case for his client; and I have seen many an honest witness confused and embarrassed under cross-examination—but the jury saw it also, and gave the verdict to his side!

It frequently happens that an expert is required to answer categorically, "Yes" or "No," a question which cannot be thus answered without giving place to unjust misconstruction. In such a situation, the expert witness should not "fence" or "dodge" (thereby giving the impression that he is afraid of the inquiry), but simply give the categorical answer required, and

then ask the privilege of further explanation. This the Court will always grant, to his complete protection and the discomfiture of the ingenious cross-examiner.

It happens sometimes, especially in mining law-suits, that an expert who has expressed in court a certain opinion is forced by later developments to change it. For instance, he may have testified to the separate occurrence of two lodes, while deeper mining has afterwards shown that these two, uniting, have become one—with lamentable and disastrous results, perhaps, to conflicting claims of ownership under the U. S. laws. Now, such changes of opinion upon later evidence are very common and perfectly honorable. And an expert who has once honestly advocated in court a given opinion has a perfect right to retract that opinion afterwards. But if he be wise, he will not announce that change as an expert under fee, in another law-suit. Let him state it in a technical essay or lecture, if he thinks it worth publishing—but not before a jury, to which it would have to be explained in connection with the unpleasant circumstance that both the erroneous first opinion and its later correction have been paid for. Moreover, an expert offering such an explanation in court will be forced either to confess that he came to a wrong conclusion the first time, or else to assert that his opinion was correct then, but has been changed by later evidence—in other words, that he might change it again upon further evidence. Such declarations will inevitably have an unfavorable immediate effect upon the case of his client, and a permanent effect upon his own reputation. This does not apply with equal force to a changed opinion which has been already publicly declared elsewhere. Yet, even in that case, it is not advisable to appear in court as an expert contradicting one's former testimony. To give voluntary expert testimony against one's former *clients* is, of course, dishonorable. But when this consideration is not involved, an unnecessary recantation, under oath and fee, is still inadvisable. In view of my former statement that the expert witness is a partisan, not for a *side*, but for an honest *opinion*, it might fairly be said that his opinion is really his client, and that if it has been overthrown he had better not become the partisan of another opinion before a judge and jury.

6. *The Advantage of Frank Publicity.*—I concluded my address

to the Electrical Engineers with the following paragraphs, which I take the liberty of quoting here, since I have no desire to modify them :

In conclusion, is there not some handy rule which would help us in every case of doubt? The Golden Rule and the Ten Commandments we all want to keep ; but they cannot always be applied in haste or with certainty. Let me suggest something practical, which has religion in it, but not enough to hurt or scare you. "*Do not do what you cannot tell ;*" or, at least, if there be good reason for not telling, "*Do not do what you could not tell without shame.*" If it is a question, whether you should take a commission or whether your employer should have it, ask him ; and then there is no trouble. If it is a question of practice, doubtful as to ethics, see how it would look in print.

Lately there has been a reign of hysteria in ethics, and it has gone too far, no doubt. Nevertheless, without deciding whether this, that or the other thing was wrong, and while still believing in my own mind that many honorable men are being persecuted for having done things which only a short time ago all the world was doing, without such criticism, I may draw out of all this the one pervading moral. How many of these things, if they had been done openly, would not plague the doers now ! Here is a railroad company, formed, after the American fashion, to drive its tracks through the wilderness, building cities as it went. And (horrible to relate !) it gave rebates to men who would help to build such cities. If the company had come out and said so, no one could have found fault justly. But it gave rebates and said nothing about it. In like manner, for many another thing, sometimes necessary, sometimes even wise, some hitherto reputable person or company has been made disreputable ; and the real trouble is that the people who did it kept it secret.

There is another point about this matter of secrecy. When you keep a thing secret you are not very likely to make a complete record of it. Now, there is nothing more foolish than not to keep your record perfectly clear. It is most humiliating to a man to be, after 30 years or so, unable to explain some particular payment which he knows was honestly made, simply because the stubs in his check-book do not tell the particulars. Keep your memorandum-books up to date and in good order, so that any one can see them. If you are ordered to do a thing which you do not approve, get the whole thing in writing, and make your record clear. We have been told upon the highest authority that men love darkness better than light when their deeds are evil. If you are not of such, why not walk in the light ?

The Cyaniding of Silver-Ores in Mexico.

BY ALBERT F. J. BORDEAUX, THONON-LES-BAINS, FRANCE.

(Spokane Meeting, September, 1909.)

THIS paper briefly describes the general outline of cyaniding silver-ores in Mexico, with special reference to personal experiments made in the Temascaltepec district.

The most important papers on the subject deal with cyaniding gold-silver-ores, the gold predominating in value, so that the treatment is nearly the same as for gold-ores, the losses of silver being considered of little importance. I describe here the treatment of silver-gold-ores containing very little gold, which is more general in Mexico than elsewhere.

The cyanide treatment, which was so successfully applied to gold-ores, did not succeed immediately with silver-ores on account of their varying composition. Gold occurs in nature usually in the native state, while silver occurs generally in combination with sulphur (argentite), and various combinations of sulphur, antimony, and arsenic.

In former times there was a complete difference in the treatment of gold-ores and silver-ores. Amalgamation, which was successful with gold-ores, was generally inadequate with silver-ores. The usual treatment in Mexico for silver was the *patio* process, the theory of which was satisfactorily explained only quite recently by Mr. Ortega and others.

GENERAL OUTLINE OF THE CYANIDE TREATMENT.

The general tendency of the present practice is to slime the silver-ore as much as possible, and in order to obtain a higher efficiency, with less loss of cyanide, and greater speed, the following lines are observed:

1. Crushing by stamps with 30- or 40-mesh screens, then crushing by Huntington or Chilean mills, through 60- or 80-mesh screens.

2. Concentration upon vanners.

3. Separation of sands and slimes with *spitzkasten* or cones.

4. Sliming in tube-mills to 100- or 120-mesh screens, or even to 150-mesh, then separation again by cones for either treating the sands separately or recrushing them in tube-mills for all-sliming.

5. Treatment of the sands, if isolated, in filter-tanks.

The slimes can be treated only by decantation; the new Butters slime-filter, as used in Nevada, does not seem to be successful with silver-ores. An "all-sliming" plant requires less outlay of capital, and less daily expense, because it does away with a second, and sometimes a third, treatment required for the sands.

OPERATIONS.

Crushing.—Crushing in solution can be done only with gold-ores, as, for instance, at El Oro, Dos Estrellas, etc. With silver-ores containing very little gold crushing in water is imperative, as there would be some heavy losses of solution in running the pulp to the concentrating-tables, pumps, tube-mills, etc. The problem is to determine the best proportion of slimes and sands to be obtained, considering different factors, such as the cyanide-expense, the length and simplicity of treatment, and the highest extraction. A comparison of the various systems used in Mexico, leads to the conclusion that the evidence tends to favor the all-sliming treatment.

The best mill for sliming is the tube-mill. In order to use it at its full capacity, the general practice is to feed sands alone, which have first been separated from the slimes in a series of separating-cones.

Cone-Separators.—These cones are used instead of *spitzkasten*, because of easier construction and more rapid action. The separators, made of galvanized iron, are open in the lower part, and have an outer rim on the upper part. The inner part is a cylinder of the same sheet-iron, reaching nearly to the bottom. The upper diameter of the cone varies from 1 to 1.3 m., and the height is from 1 to 1.5 m. The pulp flows on top of the cylinder and falls to the bottom by gravity, the speed of the flow being regulated with a valve. The average product, with pulp from a 60- or 80-mesh screen, is about 45 per cent. of sand and 55 of slime. The slime can be sent to a second set of cones for a more complete separation if desired.

Tube-Mills.—The construction of the tube-mill is so well known as to require no description here. The following notes are taken mainly from operations made at a 40-ton plant at Temascaltepec, State of Mexico, during a run of four months. Additional data are taken from Dos Estrellas and other plants.

The tube-mill at Temascaltepec was 4 m. long, with an inner diameter of 1.2 m. It was operated at from 18 to 27 rev. per min., the best efficiency being obtained with 18. The power at the start was 50 h.p. and 20 while running.

The results, after three months' run, were: Capacity per 24 hr., 56 tons of pulp; production of slime, 14 tons; pebble-consumption per ton crushed, 3.9 kg. The flint liners only began to wear after a run of three or four months; cast-iron liners last much longer. The best result was obtained with heads passing the 60-mesh screens and a 120-mesh discharge-screen.

For further sliming, the outlet of the tube-mill was reduced to 13 cm. by fitting a pipe and valve to control the discharge. It was impracticable to reduce this outlet below 13 cm., since the tube-mill would then get filled entirely and discharge through the inlet.

From the tube-mills the pulp is fed to another series of classifiers, or cones, in which the cyanidation is begun. Either there is a special plant for sand-treatment, or all the ore is slimed to undergo the same treatment.

CYANIDATION AND AIR-AGITATION.

Sand-Treatment.—The sand flows directly to the collecting-tank for drainage, which lasts from 36 to 48 hr. This step, however, permits the use of a much weaker solution, and a corresponding economy of cyanide, since the sand-moisture is from 45 to 50 per cent. After drainage, the sand is fed to filter-tanks with a special filter-bottom consisting of a wooden lattice frame-work, covered with a layer of cocoa-matting, over which is stretched ordinary canvas. The depth of these tanks is from 1.2 to 1.5 m.

The sand carries about 16 per cent. of moisture. According to the acidity of the ore, caustic lime is added, amounting to from 2 to 6 kg. per ton.

Each tank, once filled to three-quarters of its height, receives

the weak solution, carrying from 0.25 to 0.30 per cent. of NaCN, generally introduced from the bottom by means of a 5-cm. drop-pipe, terminating in a T. This operation lasts from 6 to 7 hr., then the charge is allowed to soak 6 hr., and filtering is commenced by opening the weak-solution discharge-valve. From time to time, during two or three days, weak solution is added to the top, and at the same time air is introduced by stopping the solution in the pipes, or more effectually with special pipes and an air-compressor. An abundance of air is more necessary with silver-ores containing very little gold than with gold-ores carrying a little silver.

The strong solution is then introduced to the amount of from 60 to 80 tons of 0.75 or 0.80 per cent. of NaCN content, which lasts 48 hr. Later, weak solution is run again as rapidly as possible, and the residue is ready for water-slucing. The efficiency of air is more complete if a second treatment can be made on a second series of lower tanks.

As the outlay of capital for a sand-treatment plant is very large, it has been necessary to do away with the sand or treat it together with the slime. The new Pachuca system treats both sand and slime together and avoids the necessity for a separation.

The cyanide-consumption is from 1.4 to 2 kg., and the zinc-consumption is 450 g., per ton of sand. The average cost of material per ton treated is but little less than \$1 (U. S.), which is a high cost.

Costs.—The total cost of sand-treatment, including freight charges, in similar conditions to those at Temascaltepec, is, in Mexican currency, about as follows:

Cyanide, 1.5 kg.,	\$1.50
Zinc,	0.30
Caustic lime,	0.12
Lead acetate and other supplies,	0.28
Labor, salaries, freight,	1.60
Power, lighting, assay-office,	0.70
Management and general expenses (40-ton plant),	0.50
Total,	\$5.00 (\$2.50 U. S.)

Although the freight-charges are in direct proportion to the distance from the railroad, the mines further south in Mexico have the advantage of lower labor-charges.

The cost of the treatment of the precipitates, including the various taxes of the Mexican government, may be estimated at from \$0.80 to \$1 (U. S.). In the central part of Mexico crushing costs about \$1 per ton, so the total cost of sand-treatment will average about \$4.50 (U. S.).

Slime-Treatment.—The treatment of slime during several months at the 40-ton plant at Temascaltepec is as follows :

The plant was equipped with (1) three upper tanks, *A*, 4.8 m. in diameter and 3 m. deep, for the water and the solution ; (2) five agitation-tanks, *B*, 6.30 m. in diameter and 4 m. deep ; (3) three filter-tanks, *C*, 4.2 m. in diameter and 0.9 m. deep ; (4) five lower tanks or sumps, four of which, *D*, were 4.80 m. in diameter and one, *E*, 6.30 m. ; each was 3 m. deep.

As shown in Fig. 1, the slimes flowing out from the tube-mill, *t*, are separated in a cone, and then raised 6 m. vertically in *D*, under pressure from a compressed-air injector, *p*, receiving air from the compressor, *m*'.

These slimes, averaging 350 g. of silver, come from ores having an average silver-content of 594 g., 42 per cent. of which was extracted on the concentrating-tables.

From 1,000 tons treated, the recovery by concentration was 243 kg. of silver. The cyanide extraction was 174 kg. of silver, or only 50 per cent. of the remainder, but it is a well-known fact that the losses at the start are always high ; it is only by degrees that the difficulties are overcome.

Table I. gives a detailed record of operations made in an agitation-tank. Such records, although far from perfect, are interesting, as it is the first time that cyanidation has been tried with the Temascaltepec ores.

TABLE I.—*Mill Record at Temascaltepec.*

Tank No. 1.	Filling.	Agitation.	Strength of Solution.		Lead Acetate.	Depth of Slimes.	Moisture.	Assay-Value of Solution.
			Before.	After.				
Feb. 15, 1908.	Hr. 38	Hr. 24	0.15	0.13	kg. 5	Meters. 1.75	Per Cent. 52	g. 365
		8	0.14	0.14	.....	.....	.....	263
		4	0.13	0.13	.....	.....	.....	197
		4	0.13	0.12	.....	.....	.....	162
		4	0.13	0.12	.....	.....	.....	145
		4	.....	.....	.....	.....	.....	126
		4	.....	.....	.....	.....	.....	.....
		4	.....	.....	.....	.....	.....	.....

The total consumption of cyanide for 1,000 tons was 1,100 kg., and of zinc about 450 kg. The high consumption of cyanide

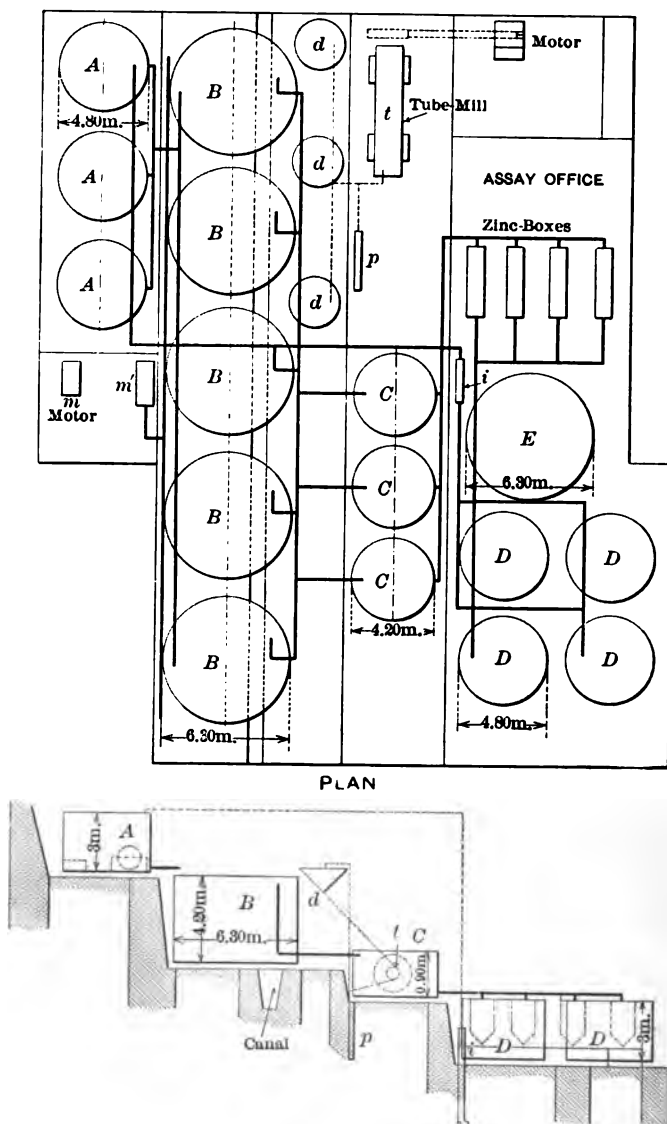


FIG. 1.—SLIME-TREATMENT PLANT AT TEMASCALTEPEC, MEXICO.

resulted from the presence of copper in some of the ores treated; in ordinary ore it would be less than 1 kg. per ton. The lime-consumption was from 3 to 4 kg. per ton.

As regards the above treatment of 1,000 tons, the poor efficiency resulted mainly from the fact that there was still a large proportion of sand mixed with the slime. The proportion of slime was only from 40 to 50 per cent., while at El Oro, for instance, after several years of experience, about 80 per cent. of particles can pass the 200-mesh and 90 per cent. the 150-mesh screen—material which can really be named slimes.

The assay-value of the tailings at Temascaltepec was about 150 g. of silver for slimes averaging 300 g. per ton. The total extraction of 50 per cent. was very weak indeed, due to an insufficient separation of sand and slime, to the presence of copper in some of Temascaltepec ores, and to losses of solution.

The compressed air was sent into the tanks by means of rubber hose and long iron pipes reaching to the bottom of the tanks, and removed from place to place every 10 or 15 min. The agitation-tanks are provided with a wooden bottom to prevent the rapid wearing of the bottom iron sheets; holes have been worn through in many instances. After each period of agitation the pulp settles during from 5 to 8 hours.

As the solution cannot filter through the slime, each agitation-tank is provided with a decantation-pipe and a floating hose with a frame of wood, by means of which the clearest solution of the tank is always supplied to the zinc-boxes. If, by mistake, or neglect, the slimes are allowed to run into the zinc-boxes, it is a great hindrance to the clean-up. This condition is the weak point of the decantation; the filter-tanks are purposely placed below the agitation-tanks to prevent mischief.

The agitation by compressed air has a double effect, oxidizing the mineral particles, which are then ready to dissolve in the cyanide, and breaking up the clay-balls into which the cyanide could not penetrate.

Each agitation-vat is provided with a discharge-opening on the bottom. The pulp, ready for discharge, carrying still about 50 per cent. of moisture, is run through this opening by means of water-pipes and tools. The slimes, falling into a masonry ditch, are run to the waste by the water-current.

There are some improved forms of tanks better fitted for agitation than those used at Temascaltepec. For instance, the Palmarejo tank, which has a conical bottom sloping at 45° , and is provided with a manganese-steel centrifugal pump, running

at a rate of 900 rev. per min., for drawing the solution and pulp continually and mixing with them air admitted through a small valve at the top of the pipes. At Guanajuato and elsewhere the compressed air is run through perforated pipes on the bottom of the tanks; but most of the air runs through the holes near the central air-pipes, while the furthest holes are rapidly shut off by the slimes, which gives very irregular results. Mechanical agitation, however, is preferable to hand-agitation.

An extraction of from 75 to 80 per cent. is reported at Guanajuato by using double treatment and filter-presses. At El Oro, Esperanza, and Dos Estrellas the extraction is from 60 to 70 per cent. of the silver, but the most important value is gold, from 90 to 95 per cent. of which is recovered.

COMBINED TREATMENT OF SAND AND SLIME.

Pachuca is again famous because of its new method of treating sand and slime in the tall tanks of the San Francisco mill. The greatest difficulty is to maintain the particles of ore in suspension in the cyanide in order to get a complete extraction. The first idea of using very tall tanks of comparatively small diameter, with an inner cylinder for compressed air, originated in New Zealand. Experiments were made according to that idea at Pachuca, with such a favorable result that the San Francisco mill was erected for a treatment of 100 tons a day. Five additional mills of similar design have since been erected at or around Pachuca.

Grothe Tank.—The Grothe tanks, Fig. 2, are of steel, 4.50 m. in diameter, and 13.50 m. high, including the conical lower part. The tank-capacity is 180 cu. m., the charge varying from 75 to 100 tons. Each tank has a cast-iron discharge-opening at the center of the bottom.

The air-cylinder, kept in position by iron legs, is 0.45 m. in diameter, open at both ends, starting from 0.45 m. above the bottom, and ending 0.45 m. below the upper rim.

An air-pipe, *b*, extends along the axial part of the cylinder. The lower end part is closed and rests upon the bottom, and an air-valve is provided at its inlet into the cylinder to allow escape of air when the pressure is over-balanced by the charge.

A second air-pipe, *a*, in the outer part of the cylinder, is used

to keep the pulp in motion during the filling or the discharge of the tank. A third air-pipe, *d*, is used for introducing air, water, or cyanide solutions.

Agitation.—The treatment consists in agitating the slimes for about 24 hr. with two or three times the weight of cyanide solution; then a rest of from 6 to 12 hr. The charge, after sufficient agitation, with the addition of slaked lime, is allowed to settle, and the clear liquor is decanted. The slimes are then pumped to the Butters filter-frame tanks for exhausting the last traces of silver-bearing solution.

At the start, the air-pressure is from 3 to 4 kg., but when the circulation is perfect, 2 or 3 kg. is sufficient. The con-

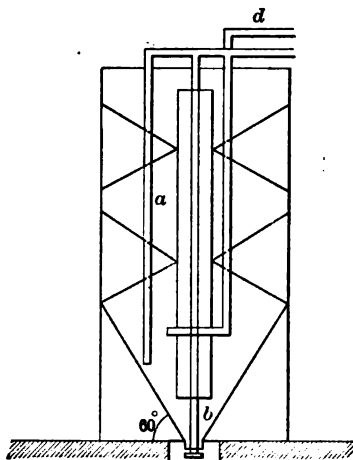


FIG. 2.—OUTLINE SKETCH OF THE GROTHE TANK.

sumption of air is from 3 to 4 cu. m. per min. An air-compressor of 15 h.p. is adequate for a 100-ton plant. The great advantage of the Grothe tank is that it permits the combined treatment of sand and slime; an extraction of 80 to 85 per cent. has been obtained with certain silver-ores. The consumption of cyanide is slightly higher than with the slime-treatment, since a stronger solution is necessary for penetrating the sand.

CYANIDATION OF THE OLD TAILINGS.

There are vast accumulations of tailings in various parts of Mexico, as at Pachuca, Guanajuato, and Zacatecas, which contain silver to the extent of approximately 200 g. per ton, and the treatment at Pachuca apparently presents no special difficulty.

FILTER-PRESSES.

For a total extraction of the silver-bearing solution still contained in the slimes after the usual treatment at Dos Estrellas, El Oro, and other mines, the slimes were passed through filter-presses of large size.

The pressure is about 10 kg. per sq. cm., which makes the slime-cakes quite hard. The general practice is to make two or three washes; the last water then contains but a trace of silver, but a single wash may be sufficient for obtaining the same result. The filter-presses are from 5 to 6 m. long, and from 1.20 to 1.50 m. in diameter, and contain from 60 to 75 filters.

Precipitation.—The following is a brief description of the operations at Temascaltepec.

Each box is fitted with a V-shaped bottom, a discharge-opening, and a valve below it. A 25-mesh screen separates the zinc-shavings from this bottom; zinc-dust is not now used. There are four rows of six-compartment iron boxes, each compartment being 1.20 m. long and 0.90 m. in width and depth.

Since practically all the precipitation takes place in the first three compartments, the zinc is successively taken out and washed on a special wooden box with a metallic screen on top. The bottom screen of each compartment is then taken out, and the whole precipitate is run out through the discharge-valve on the same wooden box as the zinc-shavings. The metallic particles of zinc remain on the upper screen, while the precipitates drop in the box and the water is filtered through the bottom. A special filter-press for precipitates gives a more-rapid result, but in a remote country, and for doing the first cyanide experiments, a wooden box is all that is necessary.

The black precipitate contained from 600 to 700 kg. of silver per ton, according to the proportion of slime that came through the filter. The precipitate is finally dried and either shipped or smelted.

SMELTING.

For melting, the precipitate is mixed with 18 per cent. of ground borax-glass, from 6 to 8 per cent. of calcined soda, and a like amount of sand and lime. It takes from 3.5 to 5 hr. to melt and pour one charge. At many mines the slimes were shipped without melting, since milling is economical only if

practiced on a certain scale. Besides, the government tax on the bullion is higher than on the precipitates, which are considered as concentrates.

COSTS AND CONSUMPTION OF MATERIAL.

Cost Per Ton.—The consumption of sodium cyanide for the treatment of slimes containing from 300 to 350 g. of silver per ton, sulphides, antimonides, and arsenides, does not run much above 1 kg. per ton. The consumption of zinc is 400 g. per ton.

The following cost-data covers a period of three months' operations with a 40-ton plant. The prices are in Mexican currency :

Cyanide, 1 kg.,	\$1.00
Zinc, 400 g. at \$0.60,	0.24
Lime, 4 to 6 kg. at \$0.02 max.,	0.12
Sundries: lead acetate, oil, etc.,	0.28
Labor and salaries,	1.26
Assay-office, power, light,	0.70
Management and general expenses,	0.50
	\$4.10 (\$2.05 U. S.)
Taxes,	0.90
Crushing,	1.10
Mining,	2.50
Total cost per ton,	\$6.55

The above data correspond to an ore averaging 320 g. of silver per ton (silver quoted \$0.65 an ounce). With 200-stamp batteries, it has been possible to reduce the total cost of treatment per ton to slightly below \$6 under special conditions.

I have omitted to say anything about cyaniding the concentrates, because the present practice is to ship them directly on account of the cyanide expenses being high. The recent progress in cyanidation may lead to the abandonment of concentration of silver-ores. The tendency is to run the pulp direct from the battery to tube-mills and the all-sliming plant.

LOSSES IN GOLD AND SILVER.

The average extraction by the *patio* process, as indicated by A. H. Bromly, may be taken at from 85 to 90 per cent. of the silver, and *nil* to 25 per cent. of the gold. In the modern

combination method, in which the *patio* is both preceded and followed by concentration, the extraction may reach 95 per cent. of the silver and 84 per cent. of the gold.

In cyanidation, the gold-extraction is from 90 to 95 per cent. The loss in silver depends chiefly upon agitation, and the extraction varies from 60 to 85 per cent. with the all-sliming method and Pachuca tanks.

Modern Progress in Mining and Metallurgy in the Western United States.

Discussion of the paper of D. W. Brunton, presented at the Spokane meeting, September, 1909, and published in *Bulletin No. 33*, September, 1909, pp. 837 to 855.

WILLIAM KENT, New York, N. Y.:—The Institute may congratulate itself on the opportunity of reading the splendid address of President Brunton. It is an admirable summary of the progress that has been made in the mining and metallurgical arts in recent years. The paper rightly gives the chief credit for this progress to the aid which has been rendered to these arts by the advances in mechanics, chemistry, and electricity. It is notable that most of the headings in Mr. Brunton's address refer to the work of the mechanical engineer, the electrical engineer, and the chemist, rather than to that of the specialist in mining-operations. It seems that the most successful mining engineer of the present day is the one who makes the most intelligent application of the inventions and designs of engineers and others who are not directly engaged in mining. A tabulation of the headings of the address, grouped as below, shows this most clearly.

Work of the Mechanical Engineer—Rock-drills, hoisting-machinery, tramming, pumping, ventilation, dredging, sampling, concentration, briquetting, fume-recovery.

Work of the Electrical Engineer—Electric machinery for hoisting, pumping, tramming, lighting and signaling, electric transmission, electric smelting.

Work of the Chemist and Metallurgist—Explosives, chlorination, cyanidation, roasting, lead-smelting, and copper-smelting.

Work of the Geologist—Economic geology.

Work of the Mining Engineer—Mine-mapping, surface-mining, timbering, tunneling; and planning and supervision of the work in general.

The mining engineer of the present day, who is in responsible charge of a large plant, finds his chief work not in doing

those things he was trained to do as a specialist, but in making use of the knowledge of geologists, chemists, and electrical and mechanical engineers. He must be to a large extent not only an engineer, but an economist, a sociologist, and even a politician. I am glad to find that Mr. Brunton is all of these. On p. 843 he touches briefly the domain of politics: "While too much 'paternalism' is certainly to be avoided, it is doubtful if anything short of government regulation and inspection of explosives, detonators, and fuses will ever bring about the uniformity necessary to safety." In this statement he places himself on the side of the wise politicians of all parties. They are all opposed to "too much" paternalism as a general proposition; everybody is, except a few cranks, but we all favor "just enough" paternalism when it relates to particular cases in which we are interested. Every civilized government in the world is gradually growing more and more paternal, and the great body of the people is being benefited thereby. It required the paternal action of the United States government to bring about the "uniformity necessary to safety" in couplings on freight-cars, and it will require either State or national government action to bring similar uniformity in the use of explosives. We may decry paternalism in general, but in matters involving safety to life and health of miners and of wage-workers generally we can scarcely have too much of it.

On p. 854 Mr. Brunton touches a sociological, if not political question. He says: "To-day we are beginning to realize that the public forms a third party, vitally concerned in the results of the work in which mining engineers are engaged." In this he strikes the keynote of our future national progress. The public is the great "third party" that is waking up to a knowledge of not only what it wants but of its power to get what it wants. One of the things it wants is a diminution of the death-rate in our mines, which now disgraces the United States. As Mr. Brunton says, "every one, no matter what his station, has a duty to society and to his fellow-men." The engineer's duty is clearly to do everything in his power to diminish the death-rate, not merely by his work as an engineer, but by his influence as a citizen in favor of at least as much "paternalism" as may be needed to safeguard the lives of our workmen.

CHARLES CATLETT, Staunton, Va.:—It is to be regretted that Mr. Brunton did not include a chapter on cost-keeping and efficiency-records. His wide experience would enable him to speak with equal authority on these subjects, and their proper development lies at the basis of success in the other departments on which he has touched.

Accounts should show what has been done, what is being done, and what can be done. In other words, they are a history of past and contemporaneous events, and are prophetic of events to come. Not uncommonly, accounts are confined to recording ancient history, so far past as to be of little value as a guide to successful operation, and make no attempt to point out the causes of the results noted. Even in this form they have value in telling the owners the loss or gain of the year, but may totally fail to fulfill their higher function of throwing light on the true efficiency of the management and of pointing out to what extent the work can be improved. A management may, by an unusual occurrence of circumstances, get results which are gratifying to the stockholders, and which add to its reputation, when its total efficiency is really very low.

We will never have thoroughly satisfactory accounts until another unit in addition to the dollar is used as a standard. The unit to be used is the "theoretically possible," and the actual results must be recorded in percentages of this possibility. These could be ultimately translated into the universal dollar. The costs in dollars and cents may be ignored for the time being, and there need be no fear that the highest efficiency, properly recorded in this way, will not also represent the maximum profit, if everything is taken into consideration. An astonishingly low cost in dollars or a disappointing high cost in dollars may not tell us anything as to the true efficiency of the work. But if the attention of the management is day by day called to how far it falls below the theoretically possible it will inevitably lead to improvement.

This develops another suggestion. The weak point to-day is not apt to be the weakest point to-morrow, nor the weak point the day afterwards. One of the essential functions of good cost-keeping is that it should point out continually and automatically the weakest point, so that it can be corrected before it becomes chronic and before it has cost too much. A system of

accounts which does this, and shows at the same time how far each department or line of operation falls short of the possible, is a system which immediately encourages efficiency.

How quickly efficiency may be increased is illustrated by the common difficulty of ascertaining what a plant is actually doing, because the whole force do better work while they know the investigation is being made, even if there is not the slightest intention to deceive. A system of accounts which continually points out a man's more serious deficiencies, and encourages him by showing him promptly where he has improved, and how much, has the effect of keeping him up to a pitch which he has not reached before, and the "impossible" of one month becomes the "possible" of the next, and the normal of the third.

It may be contended that there is no fixed standard for the "theoretically possible" in any department, and that it can be determined only by investigation and experiment, and that it is different at different times. It is true; but the mere investigation and experiment to determine the "possible" at any particular period must increase the efficiency. From the percentage stand-point it makes little difference if the standard varies. The main question at any period is whether the efficiency is 50, or 75, or 90 per cent. of the possible.

It may also be contended that it is possible for a manager to fix on such a low standard as to make his record for efficiency higher. Of course it is, and it is possible for him to falsify his accounts, and one is about as likely as the other. The good men, and they carry the day in the end, know that they are doing honest, careful, conscientious work, and they will want to know the truth as nearly as possible. They will want to know what will help them, and are perfectly willing to stand on their records, and only want the facts in such form that they may be protected from improper criticism, which is certainly not true with the present method.

The market-values of railroad stocks have not decreased since uniform accounting has been required; rather the contrary. Neither would mining companies suffer by reason of uniform accounting. Nothing could be of greater service than a system of accounting which would carry the sanction of Mr. Brunton's approval, and which would be accepted, at least by all new mining companies, as a standard to follow, until gradu-

ally it would be universally adopted. Then the engineer who had to examine into a company would have a reasonable expectation of ascertaining within a moderate time those things which it ought to be the function of accounts to reveal.

WALTER O. SNELLING, Pittsburg, Pa. (This discussion is approved by the Director of the U. S. Geological Survey):—Mr. Brunton has succeeded admirably, in his discussion of recent progress in mining and metallurgy, not only in calling attention to the advances which have been made, but also to those directions in which the need for further improvement is most urgent. Particularly in his brief references to explosives he has touched many salient points, and as it happens that the U. S. government is already, through the Technologic Branch of the U. S. Geological Survey, making investigations along some of the lines which are mentioned, I believe a brief description of the work being carried on, and a statement of some of the results already accomplished, will be of interest.

In May, 1908, Congress authorized the establishment of a station for the investigation of accidents in coal-mines, and the work was taken up by the Technologic Branch of the U. S. Geological Survey, under the direction of Dr. Joseph A. Holmes. Pittsburg was selected as the location of the testing-gallery, both because of its position in almost the geographic center of the great coal-fields of Pennsylvania, Ohio, Indiana, and West Virginia, and because natural gas was available there which was of the same percentage composition as the average fire-damp found in coal-mines, thus enabling tests to be made in the presence of such gas mixtures as are encountered in actual mining-practice.

Even the most cursory examination of the causes of accidents in coal-mines shows that the improper use of explosives, and the use of improper explosives, is directly or indirectly to blame for a large percentage of the accidents which occur. Attention is sometimes called to the fact that statistics show that many more men are killed each year by falls of side and roof than are killed as the direct result of explosions, and from this fact the conclusion is drawn that the study of mine-accidents cannot greatly reduce the death-rate. This reasoning is most faulty, for careful study not only shows that the many accidents

which are the direct result of explosions can be in a large measure prevented, but also shows that falls of roof and sides are themselves very often the indirect result of the improper use of explosives; the constant firing of excessive charges, and the firing of shots "on the solid," being factors of great importance in so fissuring and breaking the surrounding strata as to make falls much more common than they would be if better mining-methods were employed, and if, by undercutting and by proper regulation of the explosive charge, the amount of the explosive was adjusted to the amount of work to be done.

As a result of preliminary investigations made with explosives, it was clearly shown that conditions very favorable to the production of mine-disasters can readily be brought about by certain types of explosive materials, and that different explosives vary greatly in regard to the readiness with which they ignite mixtures of fire-damp and air. Ordinary black blasting-powder, for example, is found to be able to ignite 8 per cent. mixtures of fire-damp and air, even when the quantity of powder used is as little as 25 g. As this quantity, somewhat less than an ounce, is, of course, too small to be of any value in mining-operations, it is evident that in a mine in which explosive mixtures of fire-damp and air are likely to be encountered, ordinarily black powder is unsafe to use. Other explosives which were examined were found to vary in regard to their ability to ignite mixtures of fire-damp, and with several explosives many charges of 1,000 g. (somewhat over 2 lb.) have been fired without causing any ignition of the mixture of fire-damp and air. As soon as the preliminary tests had clearly shown the directions which the investigation of explosives must follow, a systematic series of tests were devised, intended to show the relative safety of all mining-explosives in the presence of such unfavorable conditions of gas and coal-dust as might be encountered in mines. In a testing-gallery, 100 ft. long, varying charges of each explosive are fired in the presence of mixtures of fire-damp and air, and mixtures of coal-dust and air, until the properties of each explosive in regard to the ignition of explosive mixtures are determined. By means of suitably constructed gauges, the volume of the gases, and the pressure produced, by the charges of each explosive are measured. The length and the duration of the flame produced by the explo-

sive are also registered upon a photographic film, and the rate of detonation, the heat evolved, and other physical and chemical qualities of the explosive are determined.

These investigations have shown that some explosives will ignite mixtures of gas and air more readily than they will ignite mixtures of coal-dust and air, while other explosives are more sensitive in regard to mixtures of coal-dust, and accordingly the standard tests have been arranged to show the relative safety of the different explosives when fired in mixtures of coal-dust and air, as well as in mixtures of fire-damp and air. Those explosives which pass all of the required tests are placed upon the "permissible" list, and it is a most gratifying fact that American manufacturers have already produced 29 explosives which have been found suitable to be so classified.

President Brunton refers to irregularities in composition of explosives as a possible cause of mine-accidents, and it is unquestionably true that any variation in the composition of an explosive, tending either to increase or decrease its strength or to change its properties in any way, may very readily be the cause of a mine-disaster. The miner gets a certain familiarity with the proper way to use the explosive, the proper charge to use, and the best manner of placing the hole; and when a change in the composition of the explosive is made, even though he loads the hole in exactly the same manner and with exactly the same charge, he may nevertheless obtain a blown-out shot.

To avoid this danger, one of the conditions required of an explosive, in order that it should remain upon the "permissible" list, is that no changes should be made in its chemical or physical nature, which in any way might alter its properties in regard to the ignition of explosive mixtures of fire-damp or coal-dust. Every explosive submitted for test by the Geological Survey is first subjected to careful chemical analysis, and such physical tests are also made as will establish its density, manner of packing, etc. If the explosive is found to answer all of the tests required, and is admitted to the "permissible" list, further samples of the explosive are taken from time to time from mines in which the explosive is being used, and these samples are transmitted to the explosives laboratory for analysis. As the samples are taken without previous notice, and from mines where the explosive is in use, any variation in the composition

of the explosive, or in its method of preparation or packing, which might alter its qualities in regard to the ignition of fire-damp, would be at once noted by the chemist. If such change in the chemical composition or the physical characteristics of any explosive occurs, the explosive is re-tested in the gallery, and does not remain upon the "permissible" list, unless the tests made show that the changes made in its manufacture have not altered its relative safety in the presence of mixtures of fire-damp and coal-dust.

As a result it is safe to say that the explosives which are on the "permissible" list will be found to be of uniform quality, and any variation of as much as 1 per cent. would be at once noted at the laboratory. I do not mean that a variation of 1 per cent. would necessarily require an explosive upon the "permissible" list to be again subjected to test, for there are many constituents in explosives which, in different mixes, vary slightly, and variations in these constituents do not necessarily bring about any change in the action of the explosive. But a variation of 1 or 2 per cent. in any ingredient of an explosive which has an important bearing upon the question of its safety in the presence of gas or dust, would at once necessitate a re-test. So far, then, as the explosives upon the "permissible" list are concerned, it may be said that the user is protected against any changes in composition or manufacture which might vary the safety of the powder in any way.

It is recognized by all users of explosives that the successful use of any type of dynamite or other high explosive depends in a large measure upon the selection of a detonator of the proper strength. When too weak a detonator is used the full strength of the explosive is never realized, and in this way it very often happens that a very large percentage of the strength of the explosive is lost. It is important, therefore, that detonators should be so classified as to enable the user to know at once the relative strength of different kinds.

This has not been the case in the past, and different manufacturers have selected wholly arbitrary methods of designating the strengths of the different grades which they manufacture; and even when the same manufacturer makes both electric detonators and fuse-detonators, or "blasting-caps," there has not even been uniformity in regard to the naming of the

strength of these two products. For example, detonators which are designated as "6 X," those called "No. 15," and those known as "double strength" electric detonators, are all of practically the same strength, and contain almost exactly the same charge.

In the course of the work with explosives a number of conferences have been held between the members of the Technologic Branch and the manufacturers of explosives. At one of these conferences the matter was brought up of the advisability of a uniform system of nomenclature in regard to detonators. It was pointed out that no advantage was to be gained by the existence of many arbitrary systems such as are at present in use, and that the users of explosives would undoubtedly be greatly benefited by the adoption of some standard method of naming the strengths of all electric and fuse detonators. The plan met with general acceptance, and I am pleased to be able to say that, as new printed matter is issued by the different companies, it is very probable that the new system of standard nomenclature will be followed.

The testing-station at Pittsburg has proceeded with its work in a very quiet way, and few people realize the great influence which it has already had in making conditions safer in coal-mining. I believe there are to-day a thousand miners living who, but for the work of the testing-stations, would have come to their death in mine-explosions during the past year. Although this statement is simply an expression of personal opinion, it is not based entirely on surmise, but is a conclusion reached from personal contact with the very conditions that the testing-station is studying. Saturday of every week is a "visitor's day" at the station, and many of the coal companies, both those near at hand and those in other States, have brought their superintendents, mine-foremen, and many of their other employees, to the station to witness the tests. I have seen these men as they have watched the tests made with coal-dust which they have brought with them from their own mines, and have seen the expression on their faces as they saw the effects of a blown-out shot on this coal-dust in the gallery. As they see the resulting explosion, they realize that just such effects are possible in their own mines through a similar charge of explosive, and they realize still

more forcibly the fact that such an explosion as they can watch in safety at the testing-station would leave no witnesses if it took place within the colliery at home. Of course all these men have heard, time and time again, that a blown-out shot is dangerous, and that coal-dust will explode, but "seeing is believing," and when they go back to their work-places on their return from Pittsburg, I can assure you that the little heaps of coal-dust in the mine mean more to them than ever before. They can now realize the danger that lies in those little heaps of dust, and we have been told many times that rules made for the safety of the miners are never lived up to so closely as they are after a visit has been made to the station.

Miners are often careless, and it is generally the carelessness which comes from ignorance and indifference. When they realize that accidents are the result of definite conditions, when they see the ease with which these conditions can be brought about, and when they recognize the fact that in so many cases they and their fellows alone are responsible for similar conditions in their own mines, they seem to have a new understanding; and I believe the vivid image of the testing-gallery at the moment of a dust-explosion is not soon effaced from their memory, nor the realization of what such an explosion in the mine would mean to them and to their families.

The usefulness of explosives to man can scarcely be overestimated, and by their aid results can be attained which, by mechanical means alone, would be difficult or impossible. The great engineering-works of to-day are, in many cases, of such magnitude as to be directly dependent upon the use of explosives. But the interests of the public in regard to explosives are, I believe, of a somewhat different nature than they are in regard to any other commercial material, with the exception of foods and drugs. When a man buys fertilizer, for example, and the fertilizer is not of the proper strength, the man loses financially by the amount which the fertilizer is below the usual standard. In the same way with most commercial articles, if these materials are faulty in composition or construction, or impaired in strength, the buyer loses a certain percentage of the purchase price which he pays. But with explosives, the case is far more serious. If of faulty composition, the buyer not only loses a certain portion of the strength of the explosive,

but because of the irregularities in composition, he may even be buying, ignorantly, a most dangerous material, which will place his own life, and the lives of his employees, in jeopardy. That explosives of improper composition have been made and sold, and are to-day being made and sold, there can be no question. It is well enough to say that the buyer of explosives should familiarize himself with their composition, but I can assure you that this is a most difficult matter. The user of small amounts of explosive cannot afford the high charges which are made for even the simplest chemical examination, and even users of large amounts of explosives find that but few chemists are available whose experience with this particular class of bodies is sufficient to enable them to draw proper conclusions. And so I cannot fail to agree with Mr. Brunton in regard to his suggestion of some general and comprehensive supervision of explosives. Conditions which allow the manufacture and sale, without the slightest restriction whatever, of bodies possessing the properties of dynamite and nitro-glycerine, cannot possibly be for the general welfare, and I know of no field which offers greater need of proper and intelligent supervision.

CHARLES W. GOODALE, Butte, Mont.:—The friction-system, designed for the recovery of flue-dust from furnace-gases, which was mentioned by Mr. Brunton as having been installed at Great Falls, has not been in use long enough to obtain a knowledge of its efficiency, but the following explanation of the system will be of interest.

Screening-tests on the blast-furnace charges of smelting-ore, and on the fine concentrate treated in the McDougall furnaces, show a high percentage of fine material, which would naturally be carried into the flues, and at a high velocity of the furnace-gases through the flues a considerable loss in dust would inevitably occur.

Before deciding upon the friction-system, a flue was built 300 ft. long, 4.5 ft. high, and 4 ft. wide, through which the furnace-gases could be drawn in measured volume and temperature, and at varying velocities. Two tests were made, maintaining a velocity of about 500 ft. per min., and with no obstructions or dust-arresters in the flue. The amount of dust

was determined per unit-volume of gas; then similar determinations were made with baffle-plates, Freudenberg plates, numerous contractions and expansions, and with wires. It was found that the wires gave nearly as high an efficiency of dust-recovery as the baffle-plates, and with very much less frictional resistance to the passage of the gases. It was then decided to build a dust-chamber of such dimensions that the furnace-gases would not have a velocity greater than 500 ft. per min. through it, and to fill this chamber with steel wires.

All the furnace-gases, from the several departments are assembled through individual flues in an uptake in the furnace-building. From the top of this uptake a cross-take leads over the smelter-buildings and tracks to the dust-chamber. The cross-take is 34 ft. wide and 20 ft. high. The main dust-chamber, rectangular in shape, is 367 ft. long, 176 ft. wide, 21 ft. high. Steel-wire netting, $1\frac{1}{2}$ -in. mesh, is bolted to the "I" beams of the roof, and at alternate intersections of the netting-wires, steel dust-arresting wires, No. 10 gauge, are hooked on, weighing about 1 lb. each and reaching nearly to the floor of the chamber. From the entrance to the chamber, and for a distance of about 150 ft., the space is fully occupied by wires, then comes a length of about 50 ft. with no wires, then 150 ft. filled with wires. In the vacant space, air-ducts, both from the basement and the roof, are provided, so that the temperature from that point on can be reduced and the condensation of arsenic effected on the wires. The purpose of this arrangement is to collect, as far as possible, the dust which is carried along mechanically by the furnace-gases in the first part of the chamber, which leaves the condensable elements to be recovered in the upper part. Experience has shown that at or below the condensing-temperature of arsenic, the wires become heavily coated, and it is therefore necessary to shake them. Provision has been made for this, but the arrangement can hardly be clearly described without a photograph or drawing. The dust-chamber is divided longitudinally by a partition-wall, and dampers placed at the lower and upper ends of the chamber make it possible to deflect all the gases through either half if it is so desired. Leading from the dust-chamber to the chimney, which is 506 ft. high and 50 ft. in diameter at the top, is a flue 1,200 ft. long, 48 ft. wide, and 21 ft. high.

In the floor of the dust-chamber there are more than 1,000 sheet-steel hoppers, arranged in 22 lines, and a complete system of tracks enables the dust to be drawn from any hopper at any time. The cross-take is also provided with hoppers, and a hopper-crane draws off the dust and conveys it to chutes leading down into the bottom of the uptake, where there are hoppers from which the material can be drawn into the charging-cars for the reverberatory furnaces.

There are 1,215,000 wires in the dust-chamber, weighing about 608 tons, and nearly 3,500 tons of structural steel in the flue-system.

Recording-thermometers and pressure-gauges have been placed at the entrance and exit of the dust-chamber and in the flue near the chimney, so that complete information regarding conditions will be available. It is my intention, when the flue-system has been in action long enough, to present a paper on this subject to the Institute for publication.

The use of wires as dust-arresters was patented in Germany by Rösing, who also took out a patent for it in the United States in 1890. The Freudenberg plates used in our experiments were of sheet-iron and were suspended parallel with the direction of the flow of the gases.

ERNEST LEVY, Rossland, B. C.:—Mr. Brunton has kindly asked me to give the meeting, as an illustration of that subdivision headed "Timbering" of his extremely interesting address, a short account of the methods used for filling excavations formed by ore mined from large masses.

I was managing for a time a mine situated on the largest known ore-mass in the world—namely, the San Dionisio lode of the Rio Tinto Copper Co., in the Province of Huelva, Spain. In order to give you a better understanding of the filling-methods employed, it will be necessary to go somewhat into other connected matters, as, for example, some of the characteristics of the ore-mass and the scheme of ore-extraction. The ore-mass, which reaches a length of about 1 km. and a maximum width of 220 m., has been developed more or less on the levels from the 7th to the 32d, which are separated by distances of 12.5 m. The development has in general taken the form of 4 by 4 m. headings, 10 m. from center to center, running

both with the length of the mass and across it at right angles to that direction, consequently, the ore left in place between each two levels may be thought of as a mass or slice of mineral with a thickness of 8.5 m. and an area equal to that of the lode at that horizon, supported on pillars which are 4 m. high, 6 m. square, and 10 m. from center to center. I am not sure if, on account of the huge size of the various masses belonging to the company, it was not originally considered that the small percentage of the mass thus extracted would be sufficient to supply all demands from these mines. However, whether this be so or not, I am of the opinion that the methods to be later employed in extracting the remainder of the ore had not been drawn up. The method later decided upon was to commence more thorough extraction by means of stopes running parallel with the width of the ore, approximately 100 m. apart and 15 m. wide. These stopes are divided into sections of from 30 to 40 m., according to the width of the mass at the place, in order that the rock-filling should not have to be carried an exorbitant distance from the stope-filling shafts. It is a characteristic of this mass that where the width is great the ore is soft and heavy, and where small, the mineral is extremely hard and stands well. Great care has to be exercised when removing the pillars in preparation for stoping, and also when excavating ground in the stopes themselves, that not too much weight has to be borne by the ground above the roof. The weight also becomes more effective when the natural fissures in the ore have become devoid of cementing material; these then form a plane of weakness. Water is a notable factor in effecting weakness along these planes by washing out soluble copper salts deposited in them at some former period. It is therefore a great necessity to catch up and remove from harm's way all water which may be found running into the mine, so that it can do no damage. A complete system of surface-drainage is resorted to in the neighborhood of the outcrop for the purpose of minimizing trouble from this source.

Timber, being scarce and expensive, is used as little as possible. As above mentioned, the spaces formed by removal of the ore are filled with rock in order to support the mass. The rock is procured from the following places: From the over-

burden, hanging-, and foot-wall, rocks removed of necessity in preparation for and during open-casting, and from any rock afforded by underground workings. This latter source is only a very small one, since, as can be well understood with such a huge and continuous mass, but little dead work is called for. Naturally, it is of great importance that the rock used for filling should be of as close a texture and as strong as can be got, in order to be capable of supplying as nearly as possible the supporting quality of the mineral removed. The filling-rock is delivered into the mine partly through the main tunnel, which strikes the mass on the tenth level, and partly through main rock-shafts, through which it is taken to such levels as desirable. The rock is put down in mine-wagons, in which it is distributed from these main rock-shafts to interior rock-shafts, which are large enough to form deposits to be drawn from when required. The train-loads are dumped directly into interior rock-shafts. These interior rock-shafts have overflow-ways at such levels as are decided necessary, and the rock flows out on to a masonry platform locally known as a "submarine," about 2 m. higher than the floor of the level. The height of the submarine facilitates the shoveling of the rock direct into mine-wagons, and thence it is distributed where needed. Each stope-section has an individual rock-shaft leading from the floor above to the bottom of the stope, and through this is dumped all the rock used to fill that stope-section. Before stoping, all former excavations made, that is, the 4-m. headings, must be tightly packed, and there must be built in the filling main passage-ways formed of side-walls and an arched roof about 4 ft. wide by 6 ft. high, in such positions as to enable the ore that is mined and rock that is to be used to be distributed as required, and also as a means of ingress to pillars yet unremoved. Places for man-ways and stope rock-shafts in the walls of these arches are left where suitable, with a view to aiding future work. Arranging the plan for these arches, etc., is a matter which requires very careful consideration, in order that the scheme may be as effective as possible. At those places where it is decided to stope, it becomes necessary, first, to fill gradually (if this has not already been done) the spaces formed by the development-galleries, in such a manner that the pillars and those sections of the neighboring pillars lying within the confines of the vertical bound-

ing-planes of the stope can be removed. Here I may mention that the stope is so arranged that the center-line corresponds with the line passing through the centers of a string of pillars between the foot- and the hanging-walls. Then, consequently, there must be extracted before the stope can be started the string of pillars, together with the adjacent 2.5 m. of the string of pillars on either side. By degrees, all spaces thus formed are filled up tightly with the rock, and the first cut is ready to be taken from the stope. The ore is removed in horizontal sections of about 2 m. thick, as follows: A 2 m. wide drift is run in the first 2 m. thickness across the center of the section under consideration, and parallel to the length of the lode, which is parallel to the width of the stope. This connects the man-ways and the rock-shafts. The remainder of the ore from this layer of the section is removed in approximately 2 m. wide contiguous drifts; they start from the end of the preliminary drift, and run north and south, or parallel to the length of the stope, and extend to the ends of the section under consideration. Before each of these secondary parallel drifts is run, the roof of the previous one is supported by solid rock-filling. In placing the filling, a sufficiently strong retaining-wall is first built at a convenient distance from the solid rock, and then the intervening space is packed tightly with rock thrown in behind and stamped down.

Varying with the supporting-capacity of the ore, more or less ground can safely be left open while being worked; but, as a rule, all spaces are filled at the earliest possible moment. I think it will be understood from what I have said that the ore gradually becomes extracted and replaced by an equal volume of rock, and it is to be expected that some day a rock-filling placed by hand will stand in place of a mass of ore which consisted of very many millions of tons.

W. L. SAUNDERS, New York, N. Y.:—No one is more competent to discuss the subject of the modern conditions in mining and metallurgy than Mr. Brunton, for he speaks not only as one in authority, but his experience and his ability entitle him to a hearing as one of the first rank among mining engineers. The moral code set forth in the concluding paragraph of his paper is worthy to be placed as a classic in the annals of the

Institute, and it should form the basis of instruction to mining engineers at the colleges.

Under Section XI., Mine-Ventilation, Mr. Brunton says :

“The ventilation and cooling of metal-mines have not yet received the attention which their importance demands. In this respect Western engineers could take profitable object-lessons from their brethren in the coal-fields.”

The importance of this subject can scarcely be over-estimated. It should surely be the province of the mining engineer not only to excavate material and treat it properly and economically, but in doing this he should study how to protect and conserve the lives of the miners. John Mitchell's figures show that four times as many men are killed in mines in the United States, in proportion to the number of men employed, as in any other country in the world. Explosions are responsible for much of this, but where explosions occur human life might be saved, provided there is a complete system of ventilation in the mine, and provided certain safeguards are employed. For instance, it has been urged by Mr. Mitchell that the introduction of compressed-air pipe-lines into all the workings of a mine might provide fresh air and even food to men imprisoned after explosions or through falls. This does not involve much expense, as mines are usually equipped with compressed-air apparatus, and the piping leading into the mine is of such a nature as to withstand considerable damage from the exterior. Furthermore, this piping at certain places, as, for instance, in the shaft, might be still further protected. Telephone wires inserted within the air-pipe might also serve a useful purpose in saving life.

Under Section VI., Underground Tramming, Mr. Brunton refers to the air- and electric locomotives which have come into general use, and he makes the statement, which no one can dispute, that each has its own field. Following this, however, the claim is made that “where the openings are dry and the roof sufficiently high and firm to carry the trolley-wire insulators, there is no question as to the desirability of using electricity.” This seems to be a rather slender hook on which to hang the interests of the compressed-air locomotive. The members of this Institute recently visited the Anaconda smelters, where we saw air-locomotives doing useful service throughout the works. The superintendent, when asked why he used air in preference

to electricity, answered, because it was better and cheaper. This is only one notable instance where air is preferred for traction purposes. There are many others, as, for instance, the Homestake, the largest and richest single gold-mine in the world, where air-locomotives do useful service not only in the yards but in the mines themselves. These installations, Anaconda and Homestake, are of the old type; that is, the simple compressed-air locomotive. Notwithstanding this, the results are satisfactory and economical. There is a new type of locomotive, built by the H. K. Porter Co., of Pittsburg, which should be able to add 50 per cent. to the saving in air-economy. This new type uses the natural heat of the mine as a reheater to expand the air between the high- and the low-pressure cylinders. Under the old system of simple compressed-air locomotive it was frequently true that the fuel required to furnish the power for the air- and the electric systems was almost exactly the same. With the new system it is claimed that under the same conditions the fuel-requirements in air will be but two-thirds of that made necessary in an electrical installation. There are some conditions where the electrical installation might prove more economical even than the compound compressed-air locomotive. Much depends upon the load-factor. With a good load-factor of from 30 to 40 per cent. of the rated power of the engines and generators furnishing the current, and with mining-conditions which permit operating locomotives at rated speed and power, it should be possible with electric locomotives to obtain efficiencies approximating those found in connection with the operation of large street-railways; but in ordinary mining conditions there is much starting and stopping, tracks are crooked and curves frequent, and the ordinarily very poor load-factor results in an efficiency in mines even below that of the simple compressed-air locomotive.

Trolley-wires in mines are always more or less a source of danger, annoyance, and expense. This is especially true in gold-, silver-, and copper-mines, where many of the levels are operated simultaneously, and where the output per level is comparatively small. In such cases it frequently requires the services of several men and large quantities of copper-wire and insulators to keep the haulage-locomotives in close touch with the various working-places. Even in cases where the open-

ings are dry and the roof high and firm, the trolley-wire becomes a menace when there is a wreck on the road or any other accident resulting in a short circuit.

Wherever the wires are carried near ore-chutes, or places which require occasional or frequent blasting, they are in danger of being ruptured or put out of service. Furthermore, the danger from fire cannot be over-estimated, inflammable material being frequently in proximity to the wires.

The long entry to the mine can obviously best be equipped electrically, but in the various ramifications of the mine compressed air has been proved to be safest and best.

The argument that the air-locomotive loses time in charging has some merit, but observation of the performance of the electric locomotive in mines proves that the time lost in handling the trolley-pole under ordinary mining-conditions is approximately as great as that due to charging the air-locomotive. In narrow drifts it is sometimes found impossible to turn the trolley-pole, and the locomotive has to be run a considerable distance with the trolley-pole in advance of, instead of trailing behind, the support. Under such conditions very slow speed and great caution are required in order not to break the poles or tear down the wiring. Ordinarily charging a compressed-air locomotive means the loss of about a minute and a half for every 4,000 ft. of travel.

It is to be regretted that Mr. Brunton dwelt so briefly upon the subject "Rock-Drills," for surely this valuable adjunct to the miner deserves serious consideration. The rock-drill has made the mining and smelting of low-grade ores profitable. Development-work, tunnel-construction, drifting and stoping are all pursued to-day to a greater extent than in olden times, because the rock-drill has been perfected to that stage of simplicity where it may be used profitably and economically. It is difficult to find in the list of mechanical appliances a machine which has been subject to greater wear and tear, or in the building of which experience is of more importance, than the rock-drill. The design of a rock-drill is not by any means everything to be considered in looking for the best. Material and workmanship are of the greatest importance, and the skill which can only come of experience when applied in the construction of this important mining-tool should surely be of value

to the miner who is seeking a reliable machine for permanent service.

Mr. Brunton says in connection with the rock-drill that "a careful engineer will often have extreme difficulty in selecting the machine best adapted for a particular service." In discussing this point I am reminded of the story told of an American who was asked to attend a dinner in England and to make an address. He went fully prepared, but did not realize that English dinners are long-drawn-out affairs, and it was getting well beyond midnight when the Chairman announced the American's name, and said, "We shall now have his address." He arose and with a polite bow said that his address was No. 33 Queen Victoria Street and he would bid them all good-night. My address is No. 11 Broadway, New York, where I trust something may be done to relieve that "extreme difficulty" to which Mr. Brunton refers in selecting a rock-drill.

THOMAS KIDDIE, Northport, Wash.:—With reference to the subject of the deposition of flue-dust "by decreased velocity," referred to by Mr. Brunton, the members of the Institute who visited the smelter of the Tyee Copper Co., at Ladysmith, B. C., in 1905, were shown an experiment there being carried out on the lines of decreased velocity—first, for the purpose of lessening the amount of cold air drawn into the dust-chamber, and, second, for the better recovery of the flue-dust.

The draft was regulated by placing a damper in the stack and turning it down until the furnace-gases came out at the doors of the furnace; it was then raised sufficiently to draw all the gases away from the furnace at the lowest practicable velocity. The dimensions of the dust-chamber were 155 by 10 by 8 ft.

A comparison of the recovery of flue-dust for two periods each of two years shows:

First period, with a velocity of 1,225 ft. per min., gave 2.007 per cent. of flue-dust.

Second period, with a velocity of 440 ft. per min., gave 3.102 per cent. of flue-dust.

These results show that with decreased velocity there was an additional recovery of 54.50 per cent. The value of the flue-dust was \$14.92 per ton.

A second plant has been similarly altered, with equally satisfactory results. In this case there were smelted copper-gold ores in which the gold-values were much higher than in the treatment at Ladysmith. Moreover, the size of the dust-chamber was much greater—namely, 300 by 16 by 10 ft. A comparison of the recovery for three years at high velocity with that of one year under decreased velocity gives:

First period (three years), with a velocity of 1,250 ft. per min., gave 2.91 per cent. of flue-dust.

Second period (one year), with a velocity of 450 ft. per min., gave 4.39 per cent. of flue-dust.

The additional recovery made under decreased velocity was, in this case, 50.8 per cent. During the latter period the higher saving in flue-dust was verified by the decrease in metal-losses. The value of the flue-dust was \$30.20 per ton. In this second case, the flue-opening from the dust-chamber into the stack, situated midway between the bottom and top of the dust-chamber, was reduced in size from 16 by 10 ft. to 2.5 by 10 ft.

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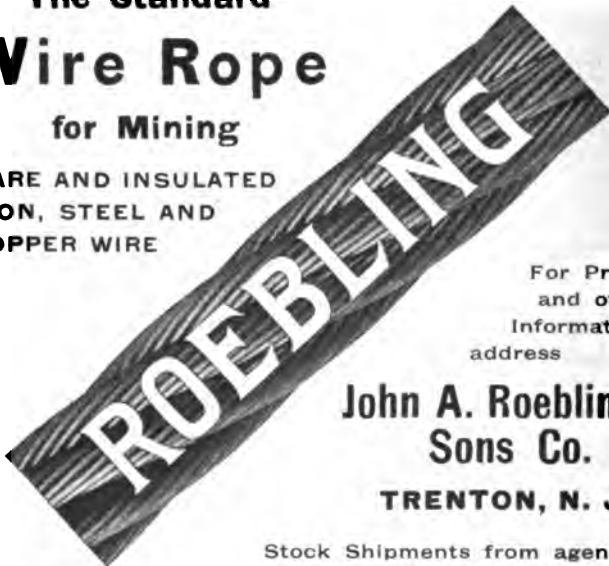
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ALDRIDGE, WALTER H. Consulting Mining and Metallurgical Engineer Canadian Pacific Railway TRAIL, B. C.	LEGGETT & HELLMANN, <i>Consulting Mining Engineers,</i> 15 Broad St., New York City. 59 California St., San Francisco, Cal. Salisbury House, London, E. C., Eng. Cables: Legmann, N. Y. Code: Bedford-McNeill.
BREWER, WM. M. <i>Consulting Mining Engineer and Geologist,</i> P. O. Box 701, VICTORIA, B. C. Connected with the Tyee Copper Co., Ltd.	RICHARDS, ROBERT H. <i>Ore Dressing</i> Massachusetts Institute of Technology BOSTON, MASS.
GREENE, FRED T. <i>Mining Engineer,</i> Silver Bow Club, BUTTE, MONT.	RIORDAN, D. M. <i>Consulting Engineer,</i> Mining Investigations especially carefully made for responsible intending investors. City Investing Bldg., 165 Broadway, New York.
KERR, MARK B. <i>Consulting Engineer</i> Mills Building, SAN FRANCISCO, CAL. Pittsburg, Gold Flat Mines Company	COLLECTIVE INDEX TO THE TRANSACTIONS OF THE American Institute of Mining Engineers. See Advertisement, page 9.

Free Public Reference Library

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American Institute of Mining Engineers.

American Society of Mechanical Engineers.

The three libraries of the above named societies have been unified and are now arranged as *one* library. This combination has helped to complete periodical sets, but there are still many serials lacking early volumes and numbers.

The following volumes are needed to complete sets, and the Library would be pleased to secure them either by gift, exchange or purchase :

AMERICAN CHEMICAL JOURNAL. Vol. 3, Nos. 8-12; 1881; Vol. 4, Nos. 1-6; Vol. 5, No. 6; Vol. 6, Nos. 1-3.

AMERICAN GAS LIGHT JOURNAL. Vols. 1-11, 13, 56-68.

AMERICAN MACHINIST. Vols. 1-2, 1878-79.

AMERICAN SOCIETY OF NAVAL ENGINEERS. *Journal.* Vol. 1, pts. 1-2, 1889.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. 1889-1840, 1901-1908.

CHEMICAL ENGINEER. Chicago. Vols. 1-5.

CHEMICAL SOCIETY, LONDON. *Journal.* Vols. 1-26.

Advertisements.

DEUTSCHE CHEMISCHE GESELLSCHAFT. *Berichte.* Vols. 1-6, 1868-74.

FOUNDRY. Vols. 1-22, 1892-1902.

GAS ENGINE. New York. Vols. 1-2.

LE GÉNIE CIVIL. Paris. Vols. 1-23, and Vol. 32.

GLASER'S ANNALEN FÜR GEWERBE UND BAUWESEN. Vols. 1-7, 1865-1889.

INDUSTRIES AND IRON. London. Vols. 16-17, 1894.

JERN-KONTORETS ANNALER. Vols. 2, 4, 13, 16, 17.

MINING AND SCIENTIFIC PRESS. Vols. 1-9, 11-19, 1860-69; 24-33, 1872-76.

NEUES JAHRBUCH FÜR MINERALOGIE, GEOGNOSIE, GEOLOGIE UND PETREFAKTENKUNDE. 1907, No. 3.

POWER. New York. Vols. 1-6, 1879-85.

PRACTICAL ENGINEER. London. Vols. 5-6, 1888-89.

PROGRESSIVE AGE. Vols. 1-14.

SCIENCE. New Series. Vols. 1-6, 9 and 13.

SCIENTIFIC AMERICAN. First series. Vols. 1 and 2, 1845-46.

SIBLEY JOURNAL OF ENGINEERING, Sibley College, Cornell University. Vol. 12, 1897-98.

VEREINS DEUTSCHER INGENIEUR. *Zeitschrift.* Vols. 1-7.

ZEITSCHRIFT FÜR ANGEWANDTE CHEMIE. Vols. 1-4, 1887-91.

ZEITSCHRIFT FÜR ANORGANISCHE CHEMIE. Vols. 22, 27, 29-38.

ADDRESS

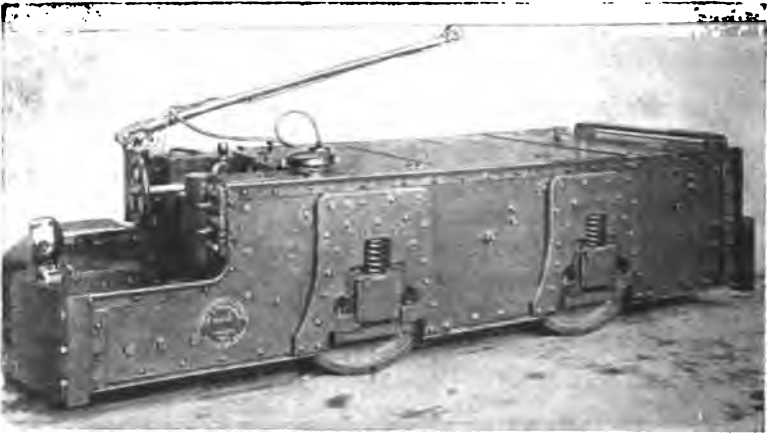
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American Institute of Mining Engineers,

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Bulletin of the American Institute of Mining Engineers.



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BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

No. 38

FEBRUARY

1910

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Single copies (including postage), \$1 each; to members of the Institute, public libraries, etc., 50 cents each.

[COPYRIGHT, 1910, BY THE AMERICAN INSTITUTE OF MINING ENGINEERS. TECHNICAL JOURNALS AND OTHERS DESIRING TO REPUBLISH ARTICLES CONTAINED IN THIS BULLETIN SHOULD APPLY FOR PERMISSION TO THE SECRETARY, AT 29 WEST 39TH STREET, NEW YORK, N. Y.]

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SECTION I.—INSTITUTE ANNOUNCEMENTS.

This section contains announcements of general interest to the members of the Institute, but not always of sufficient permanent value to warrant republication in the volumes of the *Transactions*.

SECTION II.—TECHNICAL PAPERS AND DISCUSSIONS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

A detailed list of the papers contained in this section is given in the Table of Contents. They have been so printed and arranged (blank pages being left when necessary) that they can be separately removed for classified filing, or other independent use.

A small stock of separate pamphlets, duplicating the technical papers given in Section II. of this Bulletin, is reserved for those who desire extra copies of any single paper.

Comments or criticisms upon all papers given in this section, whether private corrections of typographical or other errors or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.

All communications concerning the contents of this Bulletin should be addressed to Dr. Joseph Struthers, Assistant Secretary and Editor, 29 W. 39th St., New York, N. Y. (Telephone number 4600 Bryant).

OFFICERS.

For the year ending February, 1910.

COUNCIL.*

PRESIDENT OF THE COUNCIL.

D. W. BRUNTON.....DENVER, COLO.
(Term expires February, 1910.)

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FREDERICK W. DENTON.....PAINESDALE, MICH.
JOHN B. FARISH.....DENVER, COLO.
(Term expires February, 1910.)

W. C. RALSTON.....SAN FRANCISCO, CAL.
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(Term expires February, 1911.)

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H. O. HOFMAN.....BOSTON, MASS.
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(Term expires February, 1911.)
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W. G. MILLER.....TORONTO, CANADA.
(Term expires February, 1912.)

SECRETARY OF THE COUNCIL.

R. W. RAYMOND, 29 W. 39th St.....NEW YORK, N. Y.
(Term expires February, 1910.)

ASSISTANT SECRETARY AND EDITOR.

JOSEPH STRUTHERS.....NEW YORK, N. Y.

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(Term expires February, 1910.)

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(Term expires February, 1911.)

THEODORE DWIGHT, CHARLES H. SNOW, R. W. RAYMOND.
(Term expires February, 1912.)

Consulting Attorneys, Blair & Rudd, New York, N. Y.

* SECRETARY'S NOTE.—The Council is the professional body, having charge of the election of members, the holding of meetings (except business meetings), and the publication of papers, proceedings, etc. The Board of Directors is the body legally responsible for the business management of the Corporation, and is therefore, for convenience, composed of members residing in New York.

INSTITUTE ANNOUNCEMENTS.

The Pittsburg Meeting.

As already announced in Special Circular No. 1 from the Secretary's office, under date of Jan. 17, 1910, the Ninety-eighth meeting of the Institute will be held at Pittsburg, Pa., beginning Tuesday evening, Mar. 1, 1910. Hotel headquarters will be at the Hotel Schenley, where a bureau of information will be maintained, and the sessions will be held in a lecture-room of the Carnegie Library, opposite that hotel. The secretary of the Local Committee is Mr. Harrison W. Craver, Carnegie Library, Pittsburg, Pa., to whom should be addressed all inquiries concerning local matters and arrangements of the meeting, outside of the technical proceedings. The control of the papers and discussions will be exercised by this office as usual. No special reduction of railroad fares for attendance at this meeting is practicable; and members will make their own arrangements in this respect.

Members and guests should engage hotel accommodations by direct and early application to the hotel selected. In case of difficulty or doubt, Mr. Harrison W. Craver, Carnegie Library of Pittsburg, the secretary of the Local Committee, may be consulted.

Details of the sessions and excursions of this meeting will be given in the program of the Local Committee, which will be furnished to each member and guest on registration at hotel-headquarters. The number of interesting and important works at Pittsburg is so great that it would be impossible for the visiting members and guests of the Institute, as a body, to visit them all; but the Local Committee will be able, through the courtesy of local firms and companies, to secure for their visitors, in addition to the general excursions, a hospitable reception at such establishments as they may severally desire to visit.

Proposed Increase of Annual Dues.

At one of the sessions of the Pittsburg meeting the proposed amendment to the Constitution, increasing the annual dues, the

consideration of which is to be postponed at the annual business meeting of February 15, will be brought up for discussion; but no vote will be taken concerning it, at this or any other meeting, without due notice to members given according to the Constitution, and accompanied with the issue of proxies enabling each member to express his decision definitely upon the said amendment or any proposed modification thereof.

Report of the United Engineering Society.

The following financial report of the Treasurer of the United Engineering Society is published for the information of members:

NEW YORK, January 27, 1910.

To the Board of Trustees, United Engineering Society:

I beg to submit herewith the report of the Treasurer as of December 31, 1909.

From the Balance Sheet submitted herewith it appears that our physical property, over and above the value of the building and our equity in the land, consists of building equipment amounting to \$16,767.72, and furniture and fixtures, \$2,921.20.

During the current year there have been added to the Real Estate Equipment account a toilet-room on the twelfth floor at an expense of \$530, and furniture and fixtures representing an expenditure of \$682.86, and including telephone booths, stereopticon, tables, chairs, etc.

It will be noted that the principal of the mortgage on the land, held by Andrew Carnegie, Esq., and amounting originally to \$540,000, has been reduced by payments from the Land and Building Funds of the Societies to \$223,000, correspondingly reducing the burden on the Founder Societies for payment of interest.

The gross operating expenses for the year were \$35,845.92, or, excluding expenditures for building equipment, \$530, and furniture and fixtures to the amount of \$682.86, a net cost of operating the building for the year 1909 of \$32,163.57, slightly in excess of 1908.

In accordance with the resolution of the Board an appropriation of \$5,000 was made out of the surplus remaining from the year 1908, and this amount (\$5,037.50) was invested in Baltimore & Ohio bonds, as an addition to the Contingency and

Renewal Fund, as provided for in the Founders' Agreement, bringing the Reserve Fund up to \$10,268.75. It is recommended that a similar appropriation be made out of the available balance for this year's operations, leaving a surplus to be carried forward of \$3,905.95.

Attention is called to the fact that we had, on Jan. 24, 1910, unoccupied floor space in the building equivalent in rental value to only 4 per cent. of the total space available for assessment, and a part of this small remaining space is under option, so that the only space available and unengaged is the room and ante-room occupied by the Trustees as Board Room, and even that is occasionally called upon for board meetings under assessment for outside parties. One of the Founders' Societies is prepared to release one or two rooms for applications from Associates, otherwise the building may be deemed fully occupied.

Your attention is directed to the small number of times the auditorium has been occupied during the year—30 times as against 27 times in 1908—and the relatively small demand for the two assembly rooms on the fifth floor, occupied 56 times in 1909 as against 68 times in 1908. During the past year the facilities of the building were enjoyed by 52 societies, Founders and Associates, as against 34 in the year 1908. The limited use made of the auditorium and of the assembly rooms on the fifth floor, the income therefrom barely covering their quota of the fixed charges, continues to be a problem in the economical administration of the building.

The Chief Librarian reports a total attendance during the year of 8,303 as against 7,231 in 1908, the day attendance showing an increase of 750 and the evening attendance of 322.

The assessments paid for the year by the Founder Societies occupying one entire floor were \$6,000 each, representing a total expenditure by each, including interest on its full principal of mortgage on the land, of \$13,000, reduced in each case to the extent the Society may have paid of part of its mortgage share. As the Associate Societies are assessed approximately \$10,000 for equivalent facilities, it will be seen that the Founder Societies are still carrying more than their proportion of the carrying charges for equivalent office space occupancy in the building.

Respectfully submitted,

(Signed) J. W. LIEB, JR.,

Treasurer.

BALANCE SHEET, JANUARY 1, 1910.

Assets.

Real estate, land,	\$ 540,000.00
Real estate, building,	1,050,000.00
Real estate, equipment,	16,767.72
Furniture and fixtures,	2,921.20
N. Y. City bonds (cost) reserve,	5,231.25
Balto. & Ohio bonds (cost) reserve,	5,037.50
Accounts receivable,	3,357.00
Library United Engineering Society,	29.05
Library, adjustment account,	30.56

Cash.

Working balance,	\$5,099.88
For reserve fund,	5,000.00
Ways and Means Com.,	1,165.08
	11,264.96
Petty cash,	500.00

\$1,635,139.24*Liabilities.*

Balance of mortgage (land), A.I.E.E.,	\$54,000.00
Balance of mortgage, A.S.M.E.,	81,000.00
Balance of mortgage, A.I.M.E.,	88,000.00
A.I.E.E. equity in building,	\$ 223,000.00
A.S.M.E. equity in building,	350,000.00
A.I.M.E. equity in building,	350,000.00
A.I.E.E. equity in real estate equipment,	3,346.61
A.S.M.E. equity in real estate equipment,	3,346.62
A.I.M.E. equity in real estate equipment,	3,346.62
A.I.E.E. payments to date in liquidation of mortgage on land,	126,000.00
A.S.M.E. payments to date in liquidation of mortgage on land,	99,000.00
A.I.M.E. payments to date in liquidation of mortgage on land,	92,000.00
Depreciation and reserve fund,	15,000.00
Ways and Means Committee, etc.,	1,165.08
Accounts payable,	1,150.00
Balance, cash, accounts receivable, furniture, etc.,	17,784.31

\$1,635,129.24STATEMENT OF RECEIPTS AND DISBURSEMENTS FOR THE YEAR ENDING
DEC. 31, 1909.*Cash Receipts.*

Balance on hand, Jan. 1, 1909,	\$ 6,510.63
Account reduction of mortgage on land,	64,000.00
Account interest on mortgage,	10,740.00
Assessment of Founder Societies,	18,000.03
Assessment of Associate Societies, offices, meetings,	27,363.29
Library account,	5,109.27
Interest on bonds,	225.00

\$131,948.22

Disbursements.

Account reduction of mortgage on land,	\$64,000.00
Account interest on mortgage,	10,740.00
Operating expense, cash expenditures,	30,445.39
Real estate equipment,	530.00
Furniture and fixtures,	682.86
Library account,	5,195.52
Bonds purchased (reserve),	5,087.50
Accounts payable (from 1908),	1,399.37
A.I.M.E. return of rentals for office,	660.00
Insurance,	2,469.49
Library adjustment,	688.21
Balance on hand, Jan. 1, 1910,	10,099.88
	\$131,948.22

OPERATING INCOME AND EXPENSES, YEAR ENDING DEC. 31, 1909.

Income.

Assessment Founder Societies,	\$18,000.03
Less A.I.M.E. refund,	660.00
	\$17,340.03
Assessment Associate Societies,	16,746.00
Assessment, miscellaneous (offices and meetings),	5,991.50
Telephone returns,	2,620.70
Miscellaneous charges to societies,	1,828.64
Interest,	225.00
	\$44,751.87

Expenses.

Operating expenses, gross,	\$32,163.57
Real estate equipment,	530.00
Furniture and fixtures,	682.86
Reserve fund,	5,000.00
Insurance,	2,469.49
Balance to surplus,	3,905.95
	\$44,751.87

(Signed) W. H. MACNABB,
Accountant.

International Congress for Mining, Metallurgy, Applied Mechanics, and Practical Geology, Düsseldorf, 1910.

As already announced in previous *Bulletins*, this Congress will meet at Düsseldorf during the last week in June, 1910. Extensive preparations are in progress, including visits to technical institutions and industrial establishments, excursions to localities of geologic interest, etc., which will have a direct bearing on the papers and addresses presented at the meeting.

Full information concerning membership, meetings and excursions, classification of subjects, etc., is given in *Bulletin No. 37*, January, 1910.

Applications for membership in this Congress should be made not later than Mar. 1, 1910. Inquiries concerning announcement of proposed papers, length and time of presentation, suggestions, etc., may be addressed to Dr. E. Schrödter, Secretary of the Committee of the Congress, Düsseldorf, Jacobistrasse 3/5, Prussia.

How to Use the "Transactions" of the Institute.

Buy a copy of the Complete Analytical and Alphabetical Index of Volumes I. to XXXV., inclusive.

If you own a full set of the *Transactions*, this Index will make the whole of it instantaneously available without detailed research into each volume separately.

If you do not own such a set, this Index will be even more valuable, for it will show you what particular papers you need to know more about, and perhaps to study. Thus, any person possessing this Index can ascertain at once what has been published in the *Transactions* on a given question, and can learn, by writing to the Secretary, what is its nature, whether it is still to be had in pamphlet form, where it can be consulted in a public library, at what cost it can be copied by hand, etc., etc.

In short, to those who own complete sets of the *Transactions*, this Index will be a great convenience; but to those who do not, it will be a professional necessity.

This volume is an octavo of 706 pages, containing more than 60,000 entries, duly classified with sub-headings, and including abundant cross-references. It has not been stereotyped, and the edition is limited to 1,600 copies. The price of the volume, bound in cloth, is \$5, and bound in half-morocco to match the *Transactions*, \$6. The delivery charges will be paid by the Institute on receipt of the above price.

Hydrographic Chart.

Owing to the great value to hydrographers of the chart contained in the paper, A Graphic Solution of Kutter's Formula, by L. I. Hewes and Joseph W. Roe (*Bulletin No. 29, May, 1909, p. 454*), a special edition for office or field use has been printed on durable cloth. Copies of this separate chart may be obtained, at a cost of 50 cents each, on application to the office of the Secretary of the Institute.

Special Notice.

Attention is respectfully requested to the announcement on pages 12 and 13 of the advertising section of this *Bulletin* concerning certain books and periodicals needed to complete sets in the Library.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

AMERICAN INSTITUTE OF MINING ENGINEERS.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays, from September 1 to June 30, and from 9 A.M. to 6 P.M. during July and August.

RULES.

For the protection and convenience of members, the following rules have been adopted :

The Secretary of each Society will, upon application, issue to any member of his Society in good standing a personal, non-transferable card, entitling him to the use of the Libraries in the alcoves of the Reading-Room.

This card, as well as any card of introduction given to a non-member, must be signed by the person receiving it, and surrendered at the desk at the time of its presentation. At every visit he must identify himself by signing his name in the registry.

Strangers who desire to enjoy the privilege of entering the alcoves are requested to present either letters of introduction from members, or cards, such as will be furnished upon application by the Secretary of each Society. The first two alcoves are free to all; and admission to the inside alcoves is given upon proper introduction.

The above rules apply to all persons except officers of the three Societies, personally known as such to the librarians.

The librarians are not permitted to lend to any person any catalogued pamphlet or volume, unless authorized in writing so to do by the Secretary or Chairman of the Library Committee of the Society to which the pamphlet or volume belongs.

Any person discovering a mutilation or defect in any book of the libraries is requested to report it to the librarian on duty.

Library Accessions.

Jan. 1 to Feb. 1, 1910.

[Copies of the list of additions to the Libraries of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers can be obtained on application to the Secretary of the American Institute of Mining Engineers.]

AMERICAN FORESTRY. (Formerly *Conservation*.) Beginning with January, 1910.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS. Transactions. Vol. I. Brooklyn, 1909. (Exchange.)

AMERICAN INSTITUTE OF MINING ENGINEERS. Monthly Bulletin. Nos. 25-36, 1909. New York, 1909.

——— Year Book, 1910. New York, 1910.

BENEFICIO DE METALES DE PLATA Y ORO POR CIANURACION. (The Treatment by Cyanidation of Gold- and Silver-Ores.) By Ferdinand McCann. Published by the Author, Mexico, 1909. (Gift of Author.)

[SECRETARY'S NOTE.—This book, although published in Spanish and addressed specially to the Mexican technical public, is not merely a translation of miscellaneous material from other languages, but a logically arranged treatise on the subject, dealing successively with the preliminary pulverization of the ores, the lixiviation with cyanide solution, the subsequent precipitation of silver and gold, and the refining and fusion of the precipitates. Under each head it furnishes a description of the different systems in use. Since the application of the cyanide process in Mexico is in some respects more advanced than in any other country, this comprehensive survey of it must possess much value for all students and practitioners. That it is in the Spanish language need not deter any metallurgist unacquainted with that tongue from acquiring it. The numerous tables and illustrations tell their own story to experts of every country; and the text is so easily understood with the occasional aid of an ordinary Spanish dictionary as to make the reader proud!—R. W. R.]

BIBLIOGRAPHIE DER DEUTSCHEN ZEITSCHRIFTEN-LITERATUR. Vol. 24. By F. Dietrich. Leipzig, 1909. (Purchase.)

CALIFORNIA. STATE MINING BUREAU. Mineral Products, County Maps, and Mining Laws of California. (Bulletin 56.) San Francisco, 1909. (Exchange.)

CALCULATION OF PUBLIC COAL LANDS. (Bulletin No. 424, U. S. Geological Survey.) By G. H. Ashley and C. A. Fisher. Washington, 1910. (Exchange.)

CANADA. MINES DEPARTMENT. Report on the Mining and Metallurgical Industries of Canada, 1907-08. Ottawa, 1908. (Exchange.)

CASE SCHOOL OF APPLIED SCIENCE. Catalogue, 1909-1910. (Gift.)

CATALOGUE DE LA BIBLIOTHÈQUE DE LA COMMISSION CENTRALE DE STATISTIQUE. Tome V. Bruxelles, 1909. (Exchange.)

CIENCIAS MÉDICAS E HIGIENE. Tomo I. (Vol. I. de los Trabajos del Cuarto Congreso Científico (1 Pan-Americano.) Santiago de Chile, 1909. (Gift of Comisión 4º Congreso Científico.)

DRY CHLORINATION OF SULPHIDE ORES. Denver, 1910. (Gift of Western Metals Co.)

- FLORIDA. STATE GEOLOGICAL SURVEY. Annual Report, 2d, 1908-09. Tallahassee, 1909. (Exchange.)
- FOREST PRODUCTS OF THE UNITED STATES, 1908. Washington, 1909. (Exchange.)
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- LEADVILLE'S COMPLEX ORES. By A. W. Warwick. Denver, n. d. (Reprint from the *Herald Democrat*, Jan. 1, 1910.) (Gift of Western Metals Co.)
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- TRANSIT PROBLEM OF NEW YORK.** N. p., n. d. (Gift of Brooklyn League.)
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T. C. EGLESTON, Denver, Colo. The Maginnis galvanized steel flume for power, irrigation, and mining canals. 32 pages.

FAIRBANKS, MORSE & Co., New York. Bulletin No. 170. The Boston Consolidated Mining Co.'s mill, equipped with 312 Nissen stamps manufactured by Fairbanks. 7 pages.

GENERAL ELECTRIC CO., Schenectady, N. Y.

The improved type H transformer. 1 page.

A view in the winding department of the transformer factory, Pittsfield, Mass. 1 page.

Bulletin No. 4679 A. Type DLC commutating pole motors. 8 pages.

Bulletin No. 4706. Curve-drawing ammeters and voltmeters—Type CR construction. 4 pages.

Bulletin No. 4707. Gasolene-electric plants for lighting and power. 24 pages.

Bulletin No. 4713. Type F, forms K-2 and K4, oil-break switches. 8 pages.

Ornamental, high efficiency arc lamps. 4 pages.

JEFFREY MANUFACTURING CO., Columbus, O.

Bulletin No. 17 on Jeffrey electric mine-locomotives. 68 pages.

Catalog No. 69 B on Jeffrey revolving, panel, and tipple-screens. 24 pages.

Jeffrey wire-cable conveyors. 24 pages.

Jeffrey standard elevator-buckets. 24 pages.

RENDALL STEEL CO., New York, N. Y. Rendall furnaces and processes, reducing ore to metal without melting, and producing wrought-iron by a direct method. 32 pages.

JAMES RIGG, London, England. The "Rigg" power-driven coal-tipples. 2 pages.

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DATA APPERTAINING TO LIGHT RAILS AND FASTENINGS. 1904.

POCKET COMPANION CONTAINING USEFUL INFORMATION AND TABLES APPERTAINING TO THE USE OF STEEL AND MANUFACTURED BY THE CARNEGIE STEEL COMPANY. 1903.

SHAPES MANUFACTURED BY THE CARNEGIE STEEL COMPANY, 1903, AND SUPPLEMENT.

MEMBERSHIP.

NEW MEMBERS.

The following list comprises the names of those persons elected as members who accepted election during the month of January, 1910:

Members.

Archibald F. Dick-Cleland,	El Oro, Mexico, Mex.
Joseph B. S. McIntosh,	Tooele, Utah.
John E. Penberthy,	Globe, Ariz.
William P. Rutherford, Jr.,	Glasgow, Scotland.
Rupert F. Vaughan,	Celebes, Ned. India.

CANDIDATES FOR MEMBERSHIP.

The following persons have been proposed for election as members of the Institute during the month of January, 1910. Their names are published for the information of members and associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or unfavorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Council, which has the power of final election.

Members.

Harry Merritt Booth,	Denver, Colo.
John Edward Butler,	Stearns, Ky.
Mel C. Butler,	Fairfax, Wash.
William R. Chedsey,	Moscow, Idaho.
William J. Davis, Jr.,	San Francisco, Cal.
James Stuart Douglas,	Douglas, Ariz.
Byron E. Eldred,	New York, N. Y.
Matthew Fraser Fairlie,	Cobalt, Ontario, Can.
George T. Haldeman,	Pittsburg, Pa.
Edwin Olaf Holter,	New York, N. Y.
David Hartwell Ladd,	Houghton, Mich.
David Lemmon,	Pioche, Nev.
Stuart Bradford Marshall,	Dunbar, Pa.
Pomeroy Cooper Merrill,	Chicago, Ill.

Joseph A. Meyerovitch,	St. Petersburg, Russia.
Everett Blaine Moore,	Fairmont, W. Va.
Charles Edward Phoenix,	Bellingham, Wash.
Joseph Wickham Roe,	New Haven, Conn.
Charles Howard Smith,	Baltimore, Md.
James Thame,	London, England.
Umenoshin Tsukakoshi,	Douglas, Ariz.
Robert Bell Woodworth,	Pittsburg, Pa.

Associate.

J. S. Piper,	Georgetown, Ky.
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CHANGES OF ADDRESS OF MEMBERS.

The following changes of address of members have been received at the Secretary's office during the month of January, 1910. The list, therefore, supplements the annual list of members corrected to Jan. 1, 1910, and brings it up to the date of Feb. 1, 1910. The names of members who have accepted election during the month (new members) are printed in *italics*.

ACKER, E. O'C., Met., Bethlehem Steel Co.....	Bethlehem, Pa.
ADDIE, ROBERT, Suffolk House, Laurence Pountney Hill, London, E. C., England.	
ARNOLD, C. E. LEN., Giroux Cons. Mines Co.....	Kimberly, Nev.
ASHMORE, G. PERCY.....	109 Lansdowne Pl., Hove, Sussex, England.
AUSTIN, EDWIN A.....	419 So. Pilgrim St., Stockton, Cal.
BAKER, C. O.....	30 Church St., New York, N. Y.
BAIRD, LOUIS.....	Maestranja 75, Guadalajara, Jal., Mexico.
BATCHELLER, JAMES H.....	Box 36, Mattapoisett, Mass.
BIDDLE, WILLIAM F.....	2321 Spruce St., Philadelphia, Pa.
BLAKESLEE, F. A., Care Taquah Mining & Exploration Co., Ltd.,	
	Tarkwa, Gold Coast, West Africa.
BOLLES, J. H.....	403 Singer Bldg., New York, N. Y.
BROWN, HARVEY S.....	River Portal, Colo.
BURRALL, FREDERICK P.....	Instructed to hold mail.
CARDENAS, ADOLFO.....	Apartado 750, San José, Costa Rica, C. A.
CARLETON, JAMES G.....	4 Gregory St., Marblehead, Mass.
CARSON, ELLARD W., Picacho Basin Min. Co.....	Picacho Basin, Cal.
CHANUTE, O.....	1138 Dearborn Ave., Chicago, Ill.
CHAPLIN, GEORGE P., Frontino & Bolivia G. M. Co., La Saleda,	
	Care Empresa Hanseatica, Barranquilla, Colombia, S. A.
CHAPMAN, JAMES E., Care Cia. Real del Monte y Pachuca,	
	Pachuca, Hidalgo, Mexico.
CHEVRILLON, LOUIS.....	Apartado 18, Bis, Mexico City, Mexico.
CHOATE, WAYNE.....	210 Security Bldg., Los Angeles, Cal.
CHURCH, JOHN L.....	P. O. Box 201, Helena, Mont.
CLARK, EDWIN M., Min. and Met. Engr.....	408 Bryson Bldg., Los Angeles, Cal.
COLE, FRANK L.....	Care American Consulate, Vladivostok, Siberia.
COLE, T. F.....	515 Lyceum Bldg., Duluth, Minn.

- COLLINS, HENRY F., Huelva Copper & Sulphur Mines, Ltd.,
Valdelamusa, Prov. de Huelva, Spain.
- CONNER, H. McK.....Hotcoal, Raleigh Co., W. Va.
- COOMBS, HAROLD L.....Box 1056, Globe, Ariz.
- CRAWFORD, HENRY E.....Care J. G. Crawford, 451 81st St., Brooklyn, N. Y.
- CREMER, FELIX.....533 Byrne Bldg., 3d St. and Broadway, Los Angeles, Cal.
- CROPPER, CECIL H., Yominil Mine, Care Casa Ses Melchers, Sucs.,
Mazatlan, Sinaloa, Mexico.
- CROSSETTE, MURRAY F.....Estacion San Antonio, Chih., Mexico.
- DAMON, GEORGE G.....Care B. M. M. Co., Magdalena, Son., Mexico.
- DARBY, THOMAS L., Civ. and Min. Engr....211 Continental Bldg., Denver, Colo.
- DAY, ARTHUR M.....Instructed to hold all mail.
- DENNIS, CLIFFORD G., San Francisco Exploration Co.,
1022 Crocker Bldg., San Francisco, Cal.
- DENNIS, FRANCIS J.....110 Sutter St., San Francisco, Cal.
- *Dick-Cleland, Archibald F., Min. Engr., Care Mexico Mines of El Oro,
El Oro, Mex., Mexico. '09.
- DISBROW, WALLACE F.....508 Commonwealth Bldg., Denver, Colo.
- DRESSEK, CLARENCE G.....Care Boston Cons. Mining Co., Garfield, Utah.
- EASLEY, GEORGE R. D.....Care Hotel Perrine, Twin Falls, Idaho.
- EMLAU, HARLAN S.....208 Newhouse Bldg., Salt Lake City, Utah.
- EVANS, GEORGE S., Mgr., Tasmania Metals Exp. Co., Ltd., Roseberry, Tasmania.
- FITZGERALD, T. F. M.....211 Sharon Bldg., Salt Lake City, Utah.
- FOHS, F. JULIUS.....Box 820, Lexington, Ky.
- FRAIZER, ISAAC P.....Box 652, Salt Lake City, Utah.
- FRECHEVILLE, R. J.....544 Salisbury House, London Wall, London, E. C., Eng.
- GAGE, EDWARD C.....Chico, Butte Co., Cal.
- GAHL, RUDOLF.....P. O. Box 554, Morenci, Ariz.
- GARREY, GEORGE H.....Care Cia Minera de Peñoles, Mapimi, Dur., Mexico.
- GARVIN, CHARLES J.....1744 Broadway, Denver, Colo.
- GEORGE, JOHN G. G.....Care "The Merchants Grill," Douglas, Ariz.
- GRASTY, J. SHARSHALL.....940 S. 19th St., Birmingham, Ala.
- GRAVE, PERCY.....Instructed to hold all mail.
- GRAY, EDWIN F.....Kotsina, Alaska.
- GREGSON, WILLIAM H.....Royal View, Lethbridge, Alberta, Can.
- HADDEN, ROBERT W., Care Thane, Barratt & Hadden, St. Stephens House,
Westminster, London, S. W., England.
- HAMILTON, WALTER R.....423 Wells-Fargo Bldg., San Francisco, Cal.
- HANCKEL, ROBERT S.....Apartado 750, San José, Costa Rica, C. A.
- HARDINGE, HAL. W.....37 Wall St., New York, N. Y.
- HART, PHILIP E.....Care Allis-Chalmers-Bullock, Ltd., Montreal, Canada.
- HAWKINS, JOHN T.....Box 1058, Colorado Springs, Colo.
- HEBERLEIN, CARL A., Suriana M. & S. Co.,
Campo Morado, Ashotla, Gro., Mexico.
- HERRICK, RAY L.....728 Equitable Bldg., Denver, Colo.
- JACKSON, WALTER H.....Mapimi, Dur., Mexico.
- JOHNSON, ROBERT R.....47 Glenmore Road, London, N. W., England.
- KANE, DANIEL B.....Room 1707, 42 Broadway, New York, N. Y.
- KENNEY, HENRY S.....201 W. 13th St., New York, N. Y.
- KILGOUR, HAMILTON.....Montana Hotel, Anaconda, Mont.
- KNUTZEN, THEODORE, Supt., Young America G. M. Co.....Lantana, Va.
- LANDFIELD, JEROME B.....Binghamton, N. Y.

LASHBROOKE, JOSEPH R.....	1618 Rockwood St., Los Angeles, Cal.
LAWRY, ARTHUR H.....	333 Vine St., San José, Cal.
LECKIE, R. G. EDWARDS, Care M. S. Logan, Box 1136, Vancouver, B. C., Canada.	
LEVENSALER, L. A.....	Cordova, Alaska.
LINTON, ROBERT.....	Ocampo, Chih., Mexico.
LIVERMORE, ROBERT.....	Care Lindsley, Townsend & Livermore, Telluride, Colo.
MCCLELLAND, JAMES F.....	Drawer C, Yale Sta., New Haven, Conn.
MCCREATH, ANDREW S.....	121 Market St., Harrisburg, Pa.
MCCREATH, LESLEY.....	121 Market St., Harrisburg, Pa.
MCDVITT, JAMES E.....	P. O. Box 21, Lowellville, Ohio.
*McIntosh, Joseph B. S., Construction Engr.....	Tooele, Utah. '09.
MARTIN, JAMES J.....	6097 Occidental St., Oakland, Cal.
MASTERS, HARRIS K.....	Care W. E. Clark, 192 West Broadway, New York, N. Y.
MASTERS, JOHN E.....	Altar, Son., Mexico.
MENTZEL, CHARLES.....	Ducktown, Polk Co., Tenn.
MERRILL, EDWARD P.....	Care The Union Club, Cleveland, Ohio.
MILNE, CHARLES N.....	P. O. Box 585, Cobalt, Ont., Can.
MITCHELL, WILLIAM S., Banker.....	60 State St., Boston, Mass.
MOORE, ROY W.....	Apartado Postal 31, Alamos, Son., Mexico.
MORRIS, FRED L.....	1043 Monadnock Bldg., San Francisco, Cal.
MOSER, GEORGE F.....	500 Currier Bldg., Los Angeles, Cal.
NACK, CHARLES, 141 Grosvenor Road, Highbury, New Park,	
	London, N., England.
NEWBERRY, ANDREW W.....	Care Ray Cons. Copper Co., Ray, Ariz.
NORBON, JOHN O.....	521 Sheldon Bldg., San Francisco, Cal.
PARKER, J. L.....	Box 21, Victoria, B. C., Canada.
PATRICK, WILLIAM B.....	1160 York St., Denver, Colo.
*Penberthy, John E., Min. Engr., Supt., Arizona Commercial Copper Co.,	
	Globe, Ariz. '09.
PESCHEL, WILLIAM M.....	91 Madison Ave., Perth Amboy, N. J.
PERRY, ROBERT S.....	Queen and Stokley Sts., Germantown, Philadelphia, Pa.
PLATT, EDWIN H., Mgr., The Revenue Tunnel Mines Co.....	Ouray, Colo.
PLAYTER, GEORGE H., Treas. and Genl. Mgr., United Zinc Cos	Joplin, Mo.
PORTER, JESSE C., Santa Rita Mine, Bluefields,	
	Nicaragua, C. A., via New Orleans
PURDY, HENRY T.....	Apartado 750, San José, Costa Rica, C. A.
PULTZ, JOHN L.....	131 E. 66th St., New York, N. Y.
RADFORD, WILLIAM H.....	606 Royal Insurance Bldg., San Francisco, Cal.
RICE, GEORGE S., Chief Engr., Board of Rapid Transit Commissioners,	
	Tribune Bldg., New York, N. Y.
RICE, GEORGE SAMUEL, U. S. Geological Survey,	
	40th and Butler Sts., Pittsburg, Pa.
RICHARDS, JOHN V., Min. Engr., Richards Bros., Exchange Bank Bldg.,	
	Spokane, Wash.
RICHMOND, A. B., Min. and Cons. Engr.....	44 W. Congress St., Tucson, Ariz.
RIGGS, GEORGE W.....	Care L. Riggs, Jr., 27 William St., New York, N. Y.
RHODES, CLARENCE E., El Oro Min. & Ry. Co., Apartado 30, El Oro,	
	Mex., Mexico.
RILEY, LEWIS A.....	437 Chestnut St., Philadelphia, Pa.
ROCHE, HARRY M.....	P. O. Box 339, Tonopah, Nev.
RUETSCHI, RUDOLF, Care Salt Lake Copper Co., 511 Herald Bldg.,	
	Salt Lake City, Utah.

- **Rutherford, William P., Jr.*, Min. Engr., Tharsis Sulphur & Copper Co.,
136 West George St., Glasgow, Scotland. '09.
- RYAN, JOHN D.....42 Broadway, New York, N. Y.,
- SCOVIL, HENRY H., Care Railway Steel Spring Co.,
30 Church St., New York, N. Y.
- SEXTON, FREDERIC H.....40 Pleasant St., Halifax, N. S., Can.
- SIEBERT, FREDERIC J.....Palisade, Nev.
- SMITH, EDWARD A.....3a Dinamarca 50, Mexico City, Mexico.
- SMITH, WILLIAM A., JR.....505 Oscar Leslie Bldg., Kansas City, Mo.
- SNEDAKER, J. ANGUS.....316 National Safety Vault Bldg., Denver, Colo.
- SPILSBURY, PERSIBOR G.....Met. Staff, Spurr & Cox, El Paso, Texas.
- STAYER, WILLIAM H., Supt., Liberty Bell G. M. Co.....Telluride, Colo.
- SUTCLIFFE, JOHN.....371 Edgecombe Ave., New York, N. Y.
- THOMAS, KIRBY, Care *Engineering and Mining Journal*, 505 Pearl St.,
New York, N. Y.
- THROPP, JOSEPH E., JR.....Care Thomas Iron Co., Hokendauqua, Pa.
- TITSWORTH, FREDERICK S., Min. Engr., Atty., Care Tittsworth & King,
446 Equitable Bldg., Denver, Colo.
- TRAYLOB, SAMUEL W.....30 Church St., New York, N. Y.
- TRIMBLE, A. J....."The Montclair," Pine and Taylor Sts., San Francisco, Cal.
- UNDERWOOD, ARTHUR J.....622 Merchants Trust Bldg., Los Angeles, Cal.
- VALLAT, BENJAMIN W.....Care Northwestern Iron Co., Mayville, Wis.
- **Vaughan, Rupert F.*, Met., Totak Gold Mining Co., Menado Residency,
Celebes, Ned. India. '09.
- VINICOMBE, R. E. B.....Post Restaute, Vladikafkas, So. Russia.
- VOGELSTEIN, LUDWIG.....42 Broadway, New York, N. Y.
- WALTER, E. W.....719 Mining Exch. Bldg., Denver, Colo.
- WARN, JOHN E., Mine Supt.....Bermajin, N. S. W., Australia.
- WARREN, HENRY L. J., Ref. Librarian, Public Library.....Denver, Colo.
- WARTENWEILER, FRED.....Napa, Cal.
- WEBSTER, PAUL W.....448 Equitable Bldg., Baltimore, Md.
- WENTZ, JOHN L.....127 So. 22d St., Philadelphia, Pa.
- WETHERBY, WILLIAM J.....Alma, N. M.
- WETMORE, E. A.....Joplin, Mo.
- WHITE, MAUNSEL, Cons. Engr. and Met., New Orleans Roofing & Metal Wks.,
P. O. Box 741, New Orleans, La.
- WICKES, GEORGE T.....Care Mrs. J. F. Winslow, Poughkeepsie, N. Y.
- WILDING, JAMES, JR.....9 Queen St., Newcastle-on-Tyne, England.
- WILEY, W. MURDOCH, Care C. L. Constant Co., 42 Broadway, New York, N. Y.
- WILLSON, FREDERICK E.....Santa Barbara, Cal.
- WISHON, A. EMORY.....Coalinga, Cal.
- WOODS, FRANCISCO J.....Apartado 161, Oaxaca, Oax., Mexico.
- WOOLRICH, ARTHUR H., Civ. and Min. Engr.....Box 27, Oaxaca, Oax., Mexico.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address on Records, from which Mail has been Returned.
Alexander, George E.,	Sparta, Ore.
Andersen, Carl,	Johnnie, Nev.
Badger, Harry S.,	Goldboro, N. S., Can.
Bartoccini, Astolfo,	214 E. 90th St., New York, N. Y.
Bassett, Thomas B.,	Cumpas, Sonora, Mexico.

Batchelder, Joseph F.,	54 1st St., Portland, Ore.
Bellam, Henry L.,	Reno, Nev.
Bouchelle, James F.,	22 Duncan Ave., Jersey City, N. J.
Brown, Frank H.,	Coppermount, Alaska.
Campa, Jose,	Mexico City, Mexico.
Cragoe, A. Spencer,	Vencedora, Mexico.
Daniel, Mark,	United Elkhorn Mines, Baker City, Ore.
Derby, Harry S.,	134 Monroe St., Chicago, Ill.
Dickson, George H.,	Lethbridge, Alberta, Canada.
Donnewald, Albert H.,	3709 Finney Ave., St. Louis, Mo.
Dougherty, Clarence E.,	41 Wall St., New York, N. Y.
Downs, M. E.,	25 Broad St., New York, N. Y.
Ekberg, Benjamin P.,	Johannesburg, Transvaal, So. Africa.
Field, Wilfrid B.,	Mexico City, Mexico.
Foster, Lewis E.,	Utah Copper Co., Garfield, Utah.
Gaines, Ambrose P.,	Dayton Coal & Iron Co., Dayton, Tenn.
Gee, Emerson,	Reno, Nev.
Geppert, Richard M.,	Ray, Ariz.
Hand, Carlton H.,	Butte, Mont.
Hawkins, Tancred,	Ballydehob, Ireland.
Herr, Irving,	47 Prentiss St., Cambridge, Mass.
Hodge, Benjamin,	St. Francis Hotel, Denver, Colo.
Hunt, Thatcher R.,	Iron Mt., via Keawick, Cal.
Jewett, Eliot C.,	2918 Morgan St., St. Louis, Mo.
Kow, Tong Sing,	Shanghai, China.
McCan, E. K.,	Braden Copper Co., Graneros, Chile, S. A.
McGregor, J. Murray,	Tokyo, Japan.
Mildon, Reginald B.,	Nacozari, Son., Mexico.
Mills, Ronald V. A.,	20 Union Sq., New York, N. Y.
Moulton, Herbert G.,	Cobalt, Ont., Can.
Muir, Thomas K.,	Portland, Ore.
Nicholas, Ralph,	Avino Mines, Gabriel, Dur., Mexico.
Parrish, Samuel F.,	Georgetown, Idaho.
Perkins, Walter G.,	McGill, Nev.
Piper, John W. H.,	Buenos Ayres, Argentine Rep., S. A.
Potter, J. A.,	41 W. 124th St., New York, N. Y.
Sandifer, Harmer C.,	El Oro, Mexico.
Schneider, Albert F.,	112 Riverside Drive, New York, N. Y.
Scott, Winfield G.,	Long Beach, Cal.
Skelding, Joseph F.,	Embreeville, Tenn.
Thomas, Richard A.,	43 Wall St., New York, N. Y.
Vidler, Louis W.,	Lookout Mountain, Colo.
Wilson, Odell,	Shingle, Cal.
Wolfe, Burton L.,	Ely, Nev.
Young, William,	Kenora, Ont., Canada.

NECROLOGY.

The deaths of the following members have been reported to the Secretary's office during the month of January, 1910:

Date of Election.	Name.	Date of Decease.
1887.	*Arthur Brock,	December 23, 1909.
1895.	†Fayette Brown,	January 20, 1910.
1894.	*James W. Fuller,	January 15, 1910.
1884.	*Ottokar Hofmann,	December 24, 1909.
1905.	*Herbert H. Light,	December 23, 1909.
1900.	*Josiah Owen,	December 19, 1909.
1899.	*H. A. Shipman,	January 2, 1910.
1907.	*Wilfred F. Wheeler,	November 18, 1909.
1900.	*Alfred F. Wuensch,	January 21, 1910.

BIOGRAPHICAL NOTICES.

Arthur Brock was born Nov. 8, 1850, at Philadelphia, Pa. After a preliminary education at private schools, he entered, in 1867 or 1868, the Philadelphia Polytechnic College, after graduating from which he was employed in the manufacture of pig-iron in Putnam county, N. Y.; the blast-furnace being at Cold Spring, and the mines some miles from that point. In 1874, he went to Europe, returning in 1875 to become superintendent of the iron department of the Philadelphia & Reading Coal & Iron Co. Leaving the service of this company in 1878, he engaged with his brother, Horace Brock, in the manufacture of iron at Lebanon, Pa. They acquired afterwards a controlling interest in the Pennsylvania Bolt & Nut Co., which was subsequently merged with other iron-manufacturing companies into the American Iron & Steel Manufacturing Co., with works at Lebanon and Reading, Pa. Of this company, Mr. Brock was President for some years, and afterwards chairman of the Board of Directors, until his death, Dec. 23, 1909—at which time he was Director of the Pennsylvania Steel Co., Trustee of the Penn Mutual Life Insurance Co., Director of the Fidelity Trust Co., and officer of numerous other corporations. Mr. Brock became a member of the Institute in 1887, and supported it loyally for 22 years, though he never found time to contribute to its *Transactions* the result of his long practical experience, which might have been invaluable to his fellow-members, but are now, through his death, irrevocably lost. May others of us imitate his honorable career in other respects, but not in this!—R. W. R.

* Member.

† Associate.

Fayette Brown was born Dec. 17, 1823, at North Bloomfield, Ohio. This town was within the famous "Western Reserve," retained by Connecticut when that State ceded its remaining claims upon Western territory to the United States and consequently settled chiefly by New Englanders, with results of no little significance in the later history of Ohio. One of these pioneers was Ephraim Brown; and the subject of this sketch was one of his nine children, brought up in the limitations and hardships of life upon what was then the frontier of civilization, yet trained in the virtues and inspired by the ambitions which create upright and effective manhood.

The inhabitants of the Western Reserve, true to their New England traditions, made early provision for education; and Fayette Brown went to a district-school, and afterwards to an academy, supplementing this preliminary course by a single year in a Pennsylvania college. But in 1841, at the age of eighteen, he was obliged to earn his own living, and became a clerk in a mercantile house at Pittsburg. At twenty-one, he became a member of the firm. In 1851, he removed to Cleveland, Ohio, and engaged in business there as junior member of a banking-house, of which he took control in 1857, conducting its affairs until the outbreak, in 1861, of the War of the Rebellion. Accepting a commission in the Union army, he served for one year, retiring in 1862, with the rank of Major, to become general manager, with headquarters at Cleveland, O., of the Jackson Iron Co., operating the first iron-mine opened on a large working-scale in the Lake Superior region. The affairs of this company were managed by Mr. Brown with conspicuous ability and success until 1887.

In 1880, together with his sons, Harvey H. and Alexander E. Brown, he organized the Brown Hoisting & Conveying Co. (later the Brown Hoisting Machinery Co.), which utilized the inventions of his son Alexander, especially in the handling of large quantities of material. The Brown system became famous throughout the world, and through its installation at Cleveland, the lake business of that port was greatly facilitated. The system was specially adapted to the unloading, transferring, storage, and transportation of raw material for the iron manufacture, and had much to do with the rapid increase in the productive capacity of iron blast-furnaces which character-

ized the period following its introduction. In many branches of this business Mr. Brown was actively interested. From about 1881 to 1906, he was President of the Union Steel Screw Co., of Cleveland, and he was also, for various periods, President of the G. C. Kuhlman Car Co., the Stewart Iron Co., Ltd., of Sharon, Pa., the National Chemical Co., of Cleveland, and Vice-President of the Brown Steamship Co., engaged in lake-transportation. One of his most noteworthy achievements, illustrating his technical, commercial, and administrative ability, was his management of the furnaces and rolling-mills of the bankrupt concern of Brown, Bonnell & Co., Youngstown, O. Taking charge of these works in 1883, he operated them as receiver for nine years, during which period he paid all creditors in full, placed the business on a firm financial footing, and not only conserved but improved the property and plant. This remarkable performance naturally excited wide attention and praise. The company, reorganized at the close of his receivership as the Brown-Bonnell Iron Co., is now a part of the Republic Iron & Steel Co.

Though not a professional engineer, Mr. Brown was intelligently aware of the value of technical training, and also, by virtue of native ability and long practical experience, well-informed and wise in many technical matters. He joined the Institute in 1875, only four years after its formation, and at a time when its future growth and usefulness depended upon the co-operation of such men. Though he modestly preferred to be elected as an Associate, he was fully qualified by his executive connection with many metallurgical and engineering enterprises to be a member. The famous discussion in 1890-91 of American blast-furnace practice, aroused by the paper of Mr. James Gayley, on "The Development of American Blast-Furnaces" (*Trans.*, xix., 932), began with the meeting of the Iron and Steel Institute in the United States, but continuing after their visit was over, clearly brought out and thoroughly explained the revolutionary improvements introduced by American ironmasters, and still regarded with doubt by their British brethren. To that discussion, at the Cleveland meeting of June, 1891, Mr. Brown, then still in charge of the iron-works at Johnstown, contributed a brief account of the practice at those works, which showed that, though he was nominally but

a business manager appointed by a court, he knew what was going on under his management, and was willing to communicate technical details for the benefit of other ironmasters. To the hearty co-operation of such men, the Institute is indebted more than words can express; but that is no reason for omitting words altogether; and, as long as I enjoy, as Secretary, the mournful privilege of preparing obituary notices, especially of the old members and associates to whom we owe so much, I shall not fail to recognize, though it be impossible to repay, that obligation.

Mr. Brown's active career was very long. When he died, Jan. 20, 1910, he was a little more than 86 years old. He had been ill for six months, and during a considerable portion of that period had suffered much, though his death, at the last, was painless and peaceful. Since 1905, he had been gradually relieving himself of business cares; but no man who has been so active for so long a time can get rid of all responsibilities at once; and many things inevitably required his attention and advice so long as he was able to give such service. But, taking no account of the considerable activities of these last five years, we have before us the record of 64 years of continuous, useful, successful work, unbroken by failure, unstained by fault, and crowned with the affection and acclamation of a great community, and of the still wider circle of a great industry.—
R. W. R.

Wilfred F. Wheeler was born May 28, 1882, at Walden, N. Y., and was graduated in 1905 as mining engineer from the University of Kansas. After a brief period of service upon the Illinois State Water Survey, he was appointed, in September, 1906, an assistant in the Industrial Division of the Department of Chemistry of the University of Illinois, and placed in charge of the investigation of the coals of Illinois. In the performance of this work, he evinced a remarkable facility and accuracy of laboratory-work, together with unusual insight into the practical problems presented, and the bearing upon them of laboratory experiments.

Mr. Wheeler became a member of the Institute in 1907, and immediately demonstrated his interest in its work by presenting, at the Toronto meeting in July of that year, a highly sug-

gestive and valuable paper on "Pure Coal as a Basis for the Comparison of Bituminous Coals" (*Trans.*, xxxviii., 621). Another paper from his pen, on "The Weathering of Coal," was published in the *Bi-Monthly Bulletin* of the Institute for November, 1908, and will be found in the next volume of *Transactions*, now in press (*Trans.*, xl., 55). In co-operation with Prof. S. W. Parr, Mr. Wheeler prepared also bulletins and monographs, elsewhere published, on: "An Initial Coal Substance Having a Constant Thermal Value;" "Alterations of the Composition of Coal During Ordinary Laboratory Storage;" "The Deterioration of Coal;" "A Series of Parallel Determinations with the Mahler and Parr Calorimeters;" "The Ash of Coal, and Its Relation to Actual or Unit Coal-Values;" "A Comparison of Methods for the Determination of Sulphur in Coal;" and "Unit-Coal and the Composition of Coal-Ash." These evidences of his professional ability and industry intensify the regret with which we record his death, Nov. 18, 1909, at the age of 27, and after only three years of useful and brilliant work. Yet in that brief period he made his mark; and he will not be forgotten by future students of the field in which he wrought.—R. W. R.

Alfred F. Wuensch was born July 29, 1855, at Marietta, Ohio. Without special preparatory professional training, he made his way to Colorado, where in 1879 he found employment as a journalist, and was necessarily obliged to acquire some acquaintance with mining and metallurgical affairs. His ambition to increase that knowledge was aided by professional friends; and in 1883 he was qualified by study, observation, and practical experience to take the position of assayer and superintendent of a concentrating-works at Santa Barbara, Chihuahua. In 1884, he became connected as a consulting engineer with Messrs. Moffat & Smith, mining operators, of Denver, and remained in that relation to the end of his life. From 1888 to 1890, he was employed as economic geologist by the Union Pacific & Rio Grande R. R. companies, and, from 1896 to 1908, was engaged in general practice as a consulting mining engineer, giving his time chiefly to the mining interests of D. H. Moffat and the First National Bank of Denver, Colo. When he joined the Institute in 1900, he was manager of the Louisville and Colorado No. 2 Mines at Leadville, having his residence at Denver. He died suddenly at Albuquerque, Jan. 21, 1910.

The Geology, Mining, and Preparation of Barite in Washington County, Missouri.*

BY A. A. STEEL,† FAYETTEVILLE, ARK.

(Spokane Meeting, September, 1909.)

DURING the summer of 1905 I was employed by the U. S. Geological Survey to investigate the geology, mining, and preparation of barite in most of the fields of the United States. The Eastern districts have been more or less completely described; the Virginia field in detail by Thomas L. Watson, in his paper, *Geology of the Virginia Barite-Deposits*,¹ and other fields in abstract, including statistics of production and references to current literature, by various authors.² There have also been published a few details of the occurrence of barite in the lead-mines of Washington county, Mo.³ The other accounts of this district are erroneous and meager, and since this field is the most important one in the United States at the present time, a detailed description of the local geology seems doubly desirable.

Barite-deposits are scattered over nearly the whole of Washington and adjoining counties, but the product is all mined from the areas indicated upon the sketch-map, Fig. 1, and is shipped from the stations of the St. Louis, Iron Mountain & Southern railway, between Blackwell and Potosi, from 45 to 60 miles SW. of St. Louis.

The topography is for the most part gently rolling, with slightly graded streams, usually less than 200 ft. below the higher hill-tops. Along Mineral fork and Indian creek are some steep bluffs and cliffs, affording good exposures of the

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† Professor of Mining, University of Arkansas.

¹ *Trans.*, xxxviii., 710 to 733 (1908).

² *Mineral Industry*, vols. ii., viii., x., xiii., xv., and xvi., under the caption "Barytes."

³ *Report of the Missouri Geological Survey*, vol. vii. (1894).

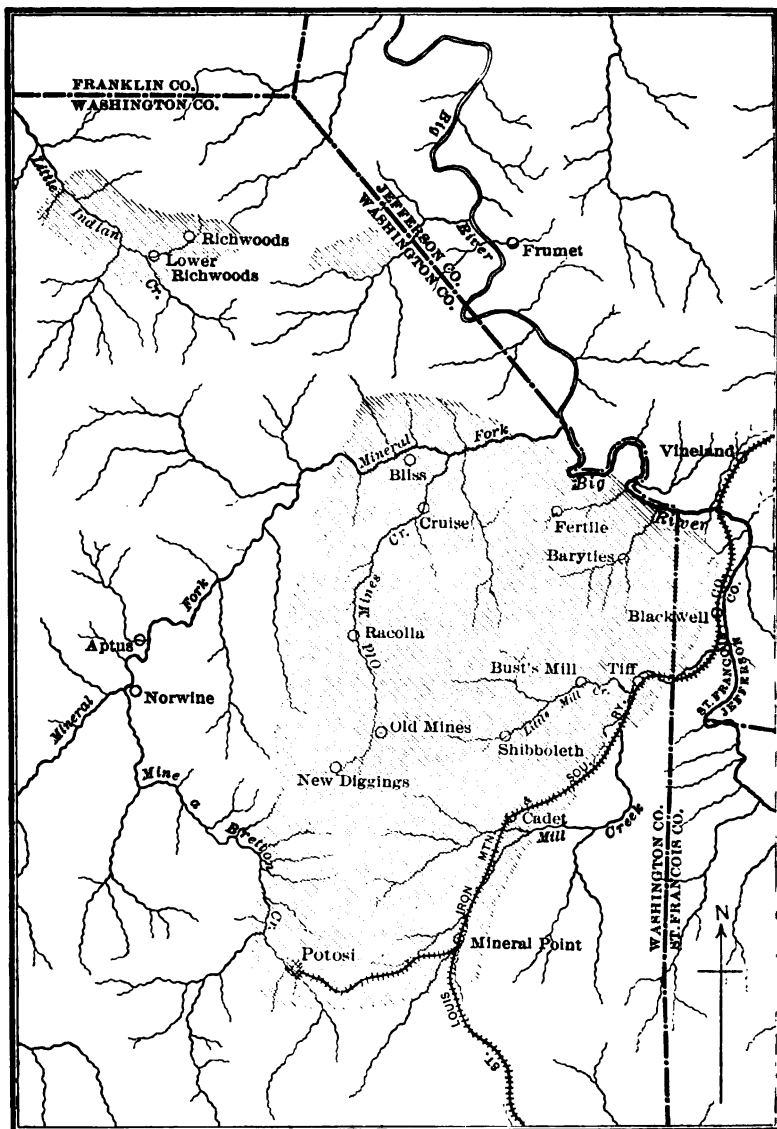


FIG. 1.—SKETCH-MAP OF A PART OF WASHINGTON AND ADJOINING COUNTIES, MISSOURI, SHOWING BARITE-REGIONS.

(Redrawn from the De Soto, Bonne-Terre, and Potosi Topographic Sheets.)

Scale, 1 in. = 4 miles.

formation. Nearly all the rest of the area is covered to a depth of from 5 to 40 ft. with residual clay containing chert, barite, etc. This over-burden greatly interferes with the study of the

bed-rock, which is exposed only at intervals in stream-beds, in a few barite-pits, and in those lead-mines which have not been abandoned.

I. GEOLOGY.

1. *The Formation and Filling of Cavities in Dolomite.*—The Gasconade limestone (of Missouri), of Ordovician age, forms the underlying rock, and is the source of the barite, which is now mostly dug from its residual clay. This rock has been quite uniformly shattered, presumably by dolomitization, since it contains from 40 to 50 per cent. of magnesium carbonate and is full of small, irregular, and non-continuous cracks. Those which have not been greatly enlarged by water are usually less than 1 in. wide and 2 ft. long. Many are very short. They have been shown by diamond-drilling to extend to a depth of more than 600 ft., and are independent of the larger deformation of the strata, which are either level or only gently folded.

A detailed study of the country-rock shows a rather complex series of geological changes. After the first shattering under the obscure conditions of dolomitization, the northern part of the district was raised to the zone of solution. During this time some of the small cracks were connected, forming long branching caves, generally from 2 to 12 ft. wide and from 6 in. to 3 ft. high, and scattered irregularly through the rock at all levels. Several are from 300 to 500 ft. long, and the main channels have a general NW-SE. direction and pitch slightly NW. Since caves formed at this time are found only in the north, a differential elevation of the region may be assumed.

At a time of depression the caves were next coated quite uniformly with chalcedony and then with clear quartz crystals up to 0.5 in. long. At the same time quartz was deposited in the small vug-like cavities which had not been enlarged. There is much quartz as far south as Bust's Mill, and a less amount beyond Potosi.

Ulrich⁴ speaks of this quartz as "drusy chert." Some of it occurs in cavities in chert, but much of it is in contact with clean dolomite, and at Ricar, near Racola, two quartz-lined, barite-filled caves are connected by a strip of brecciated car-

⁴ *Bulletin No. 267, U. S. Geological Survey* (1905).

bonate rock cemented with clear quartz, etc. It is therefore assumed that most of the small cavities were formed before the deposition of the quartz, and probably after the formation of the chert.

It is believed that the faulting and extensive fissuring of the district was the next event after the deposition of the quartz. Some of these fissures now filled with barite are free from crystallized quartz and intersect the quartz-lined caves, so this fissuring is clearly later than the quartz-deposition. These cracks are sometimes in intersecting groups like stockworks, but are more often long straight fissures, sometimes traceable for several hundred feet upon the surface and occasionally exposed by mining to a depth of from 50 to 100 ft. without closing up.

In many parts of the field crusts of galena were deposited upon the quartz, and also upon the bare walls of the fissures. Three carloads of copper-ore, mostly as carbonate but with some chalcopyrite, were shipped from Bliss. According to Robert McClay, this ore was found in a single cave next the quartz, and therefore corresponds in age with the earliest galena. (No other occurrences of copper were noted in this field.) After this deposit of sulphides the remaining space of all of the larger quartz-lined caves and of the fissures was completely filled with white barite, which cleaves into curved plates resembling those of albite. In many places masses of galena are scattered through the barite, which indicates that the deposition of the sulphides continued after the first barite was brought in.

Other localities outside of Missouri show quartz crystals on barite groups, and even pieces of quartz showing casts of barite which has been dissolved by weathering. Since these specimens are durable, and a somewhat careful search failed to find any of them, it seems safe to conclude that most of the quartz was deposited before any of the barite. (Winslow reports specimens from Washington county showing a thin deposit of quartz upon galena, but these must be very exceptional. Specimens of barite upon quartz are very plentiful.)

What is thought to be a second period of shattering seems to have followed this first deposition of barite. Openings of this second set are scattered among the others and are entirely free from quartz, which would naturally have affected all then-

existing openings before completely sealing so many of the small vugs. The brecciated appearance of the rocks at New Diggings and other places, as well as the angular shape of some of these cavities and their great irregularity and number, seems to preclude the idea that they were formed wholly by sub-aërial solution. On the other hand, they do not represent brecciation by movements of the strata, and are therefore assumed to have attended the final dolomitization of the rock.

After the second shattering, both sets of openings were subjected to enlargement by water. A few of the first set had the quartz coating loosened, but most of these and some of the second set were unaffected. At the next submergence, the larger cavities in the north were completely filled with barite, and those south of Little Mill creek were coated with dolomite crystals of larger size in the larger openings. The ends and feeder-cracks of the smaller openings were completely filled by this dolomite and occasionally some calcite. Since dolomite would not be readily deposited upon the quartz, and would be easily weathered off, the relative age of the two sets of openings is assumed from the entire absence, in the latter, of quartz showing casts, or found on crystals, of dolomite.

A few cavities still lined with dolomite crystals were seen at Potosi and New Diggings, and dolomite crystals were abundant in the southern part of the field, as shown by the casts upon the back of the barite groups. Since there is no evidence of crystallized dolomite in the northern part of the field, another differential movement may be assumed.

Since the dip of the strata is about parallel to the present surface, and the amount of residual deposit merely varies with the local topography, we cannot explain the difference in the dolomite by differential erosion. Published analyses show no important regional variation in the amount of magnesium in the rock.

In a few places the dolomite was followed by a layer of marcasite, then there was a general deposition of barite upon both the dolomite and marcasite. This barite was never seen completely filling the dolomite crystal-cavities, but is in the form of sheaves of crested crystals. The marcasite was seen at New Diggings, where mining in the bed-rock was still being carried on. In other places it is represented by occasional layers of

hard limonite upon the backs of residual barite groups. More rarely there are shots of limonite imbedded in the barite, showing an overlap in the time of deposition.

The dumps at New Diggings show many specimens, with marcasite followed by barite directly upon the massive dolomite, and a few with barite upon the crystals of dolomite without marcasite. Unfortunately, the original relations could not be determined, since this shaft was full of water. In most other places barite in less-continuous crusts is common directly upon the dolomite. With the barite is often a little galena.

After this second general deposition of barite, the entire region seems to have been raised to the zone of solution. In the north new caves were opened along the old ones which have a floor or roof of the earlier barite. There are also many small separate openings still free from filling, which at times suggest a third period of brecciation, but they are generally continuous, like small caves. In the south, among the cavities containing dolomite crystals are also many of these small openings, and some large caves free from quartz and dolomite. These were probably formed at the same time of general elevation by the solution of some of the dolomite linings or the enlargement of new joints or fractures.

This third set of caves was then submerged, and in them were deposited a few large groups of crested barite, occasionally including cubes of galena or studded with them. This barite is attached directly to the decomposed clay-coated walls of the caves, and seems to be secondary. In some of these caves the walls were coated in places with small calcite crystals. Winslow reports one large scalenohedron of calcite imbedded in barite at Potosi. At Richwoods were seen cross-sections of caves with old barite floors and completely filled with calcite which will cleave into rhombohedra 6 in. on a side. There are other caves now above water-level, with the old barite floor thickly strewn with eroded scalenohedra of calcite, and with the roof studded with smaller barite groups and calcite crystals. These caves are apparently free from stalactites, and the calcite and barite have therefore been deposited below water-level.

At a slight depth below water-level the barite groups seem to be finished by a layer of very small needle-like crystals of barite. They are still later coated in places with a stain of

limonite, which does not collect on the other minerals. This result is probably caused by the attraction of barium sulphate for ferric salts, which makes it necessary to remove the iron from solutions before precipitating the barium in quantitative analysis.

At a greater depth, at New Diggings, there are recent contemporaneous deposits of galena, clear ruby sphalerite, and barite upon the older barite. This last barite is in small, pure white sheaves and seems to be still growing.

The weathering-surface of the bed-rock intersects many of the caves, which are then filled by a recent deposit of fine red clay. This obscures the relationship of the minerals in many of the exposures of bed-rock. It is, of course, the last of the cave-deposits.

It is possible that the second set of fractures (those lined with dolomite) may have been formed before the first introduction of barite into the fissures. In favor of this is the failure to find any dolomite upon barite, while barite is frequently found upon dolomite. When they are associated, the marcasite is later than the dolomite, and generally older than the barite.

As to the first reason, dolomite is so soluble that it would during subsequent changes be easily removed from the barite. It would also deposit upon the abundant massive dolomite or its own crystals rather than upon the barite, and if the first set of fissures were entirely filled with barite no dolomite could be deposited upon it. All barite which showed casts of dolomite was in the form of sheaves or incomplete fillings of openings, and probably later than the first barite deposited. As to the second, there are in immediate association specimens without the marcasite and others without the dolomite crystals. This I am unable to explain.

As evidence that the fissures were filled with barite before the second brecciation of the rock, there are straight and sometimes branching fractures entirely filled with clean massive barite in contact with fresh unaltered walls, and in their immediate vicinity many irregular cavities lined with dolomite and only partly filled with barite in scattered sheaves.

Besides those fractures, which I have seen, Mr. Robertson⁵ describes such a fissure near Potosi intersecting "absolutely

⁵ *Report of the Missouri Geological Survey*, vol. vii., p. 679 (1894).

unaltered" rock, which was followed to a depth of 60 ft. The rock was full of quartz-cavities, but dolomite was not mentioned. On page 678 he mentions another fissure near the Bugg shaft, near Potosi, in rock with dolomite-lined cavities. This fissure contained lead and barite, but had been affected by later solutions. It was from 0 to 10 ft. wide, more than 112 ft. deep, and 1,300 ft. long. Such sharp fractures would not be likely to form in a rock so full of cavities poorly cemented with dolomite, and containing quite large and irregular openings. On the other hand, if fissures filled with barite were already present, they would resist the shattering and would obstruct the dolomite solutions, and so tend to prevent intersections of the two sets of openings. No intersections were found, but there were only a few exposures for study. Many of these, however, showed dolomite openings near the barite-fissures.

It is also difficult to understand how these fissures could be so completely filled and the other sort of openings receive only scattered deposits if both existed at the time of the introduction of the barite. Even those fissures that have been enlarged by solution show slabs of barite which evidently once completely filled a smaller opening. In the north, where there are good exposures, the presence of a few scattered barite sheaves of later growth upon the walls of reopened caves with barite floors and feeders shows clearly that barite has been deposited at more than one period of submergence, with at least one elevation of the region intervening. Specimens were also found showing barite sheaves, probably of the second period, growing upon the clean outer surface of drusy quartz, with apparently later barite continuing the growth over upon the iron-stained back of the quartz. This proves an extensive interval of solution between periods of barite-deposits. The barite-fissures are found over an extensive area, and are clearly independent of the somewhat local crystallization of dolomite.

It seems more probable, therefore, that the first main introduction of barite was, as stated, before the formation of the dolomite-lined cavities.

2. *Summary of the Geological History of Washington County.*—In Archæan time the St. Francois mountains of Missouri were formed of red granite and porphyry, with dikes of a basic rock.

During a long pre-Cambrian period they weathered to a low irregular dome with outlying prominences. During this time the veins of iron-ore were formed, and they were otherwise affected by circulating solutions. During Cambrian and later times they were probably never wholly submerged, but sediments were deposited upon their flanks and in the valleys, all dipping roughly parallel to the old land-surface. The first sediments are of land-wash and contain in places the bedded iron-ores, which were succeeded by limestones with local beds of sandstone and many unconformities and other evidences of oscillation in level. Washington county has been land-surface continuously, or only submerged for brief intervals, from Carboniferous or possibly earlier time to the present. During this period there was much erosion, and the outlying granite knobs of the Archæan mountains were exposed in southern Washington county.

Some time after the deposition of the Gasconade limestone, the chert was formed in it. Later, the rock was rather minutely fractured over a wide area, and the region along Mineral fork and Indian creek raised sufficiently to permit the formation of many small limestone caves. The entire region was then submerged and all existing openings lined with quartz. There was next a rather severe fissuring and faulting, followed by the introduction of barite with more or less lead, copper, and iron sulphides and probably some zinc sulphide.

This period was followed by another shattering, which was less pronounced in the northern part of the county. Many of these new fractures were soon enlarged by water, and near Potosi the country was lowered and the openings lined with dolomite crystals, which were followed in a few places by a layer of marcasite, and generally by barite in scattered sheaves, which usually also formed upon the marcasite. After the marcasite was deposited, the lowering seems to have become more general, and the few caves in the northern part of the field were rather completely filled with barite.

A general elevation followed this, and the large and small caves were formed throughout the barite-field. Upon the next submergence, a little barite was deposited in them in isolated groups along with more metallic sulphides. Calcite in double-pointed scalenohedra was also deposited at this time or soon

afterwards. When in contact with oxidizing solutions, the free surface of the barite became coated with limonite, which is usually the last deposit from solution.

At intervals ever since the first introduction of the barite, the massive dolomite has been dissolved by weather, and the barite and galena and other insoluble matter has accumulated in residual deposits. The fine part of this is generally washed into those caves which came to the surface of the rock.

3. *Comparison with Other Districts.*—All of the barite of Washington county has clearly been deposited in free open spaces. It is all very white, rather soft, and either in poorly-cleavable masses from completely-filled openings, or in sheaves with ridged surfaces. When attached by the side, these groups are spindle-shaped, but more commonly they are attached at one end and are roughly heart-shaped. They weigh up to 20 lb. each, and cleave like the massive barite. No one has seen or heard of clear or translucent barite, or any of the common tabular crystals, occurring in this county.

At Morrilton, Franklin county, just beyond this field, is one nearly-vertical cave, 60 by 100 ft. in section, filled with very unctuous clay containing groups of beautiful blue, square, tabular crystals of barite, sometimes weathered white on the edges and sometimes attached to pieces of chert. In this clay were also found a few large barite stalactites covered with fine, colorless, tabular crystals of barite. Aside from this occurrence, all the barite seen in the central counties of Missouri was in the form of "slabs," which had completely filled flat caves, or groups of vertical fissures. Winslow mentions blue barite crystals upon the dumps of the Virginia mine in Franklin county.

In the fluorspar-region of Crittenden and Caldwell counties, Ky., there are some few veins of barite containing strontium, and mixed with fluorite and white calcite. At the time of my visit no barite was being mined there. Some details of this occurrence have been given by F. Julius Fohs.⁶ A complete account will soon be published in another bulletin by the same author, which will include an account of the barite of central Kentucky.

Near Cleveland, Tenn., and in western Virginia, most of the

⁶ *Bulletin No. 9, Kentucky Geological Survey (1907).*

barite fills groups of fissures and not caves in the Knox dolomite, and there has been a great deal of metasomatic replacement of the wall-rock. At Honaker, Va., there are some small masses of sulphur in the barite, as well as iron sulphide. At Sweetwater, Tenn., in the center of the belt, some barite has incompletely filled fissures, as in Washington county, Mo. It was, however, in the form of uniform layers or crusts upon the walls with imperfect, small, tabular crystals on the surface. Here also was a much larger amount of earlier marcasite and some contemporaneous fluorite.

Further east in North Carolina and Virginia the barite is quite translucent, and is said to occur in distinct fissures in gneiss, quartzite, or sandstone. At Evington, Va., the barite seems to have replaced parts of lenses of marble in a micaceous schist.⁷ The mines were so largely abandoned that all the exact relations could not be worked out at the time of my visit.

4. *Origin of the Barite.*—The origin of the barite has been discussed only by Mr. Winslow, of the Missouri Geological Survey. He thinks that the barite, together with its associated lead and zinc, has accumulated through the agency of descending solutions, gathering the barite from the weathering of the dolomitic rock. In favor of this hypothesis is the presence of appreciable, although very small, amounts of barite in the dolomite (from 0.001 to 0.005 per cent.); the assumed absence of definitely-proved fissures extending to great depths; the long period and considerable amount of denudation; the evidence of the Flat River lead-mines; and the stalactites of barite in Franklin county.

On the other hand, Winslow himself says that both the porphyry and the granite in the southern part of Washington county and beyond show barite in visible amounts. (He especially mentions the porphyry at Hogan, Iron county.) It seems safe, therefore, to assume that, in common with most igneous rocks in which it has been determined, these rocks contain barite in much greater proportion than does the dolomite. (No printed reports of the quantitative determinations of the percentage of barium oxide in these rocks can be found.) These Archæan

⁷ Watson, T. L. Geology of the Virginia Barite-Deposits, *Trans.*, xxxviii., 717 to 719 (1903).

rocks underlie the entire region, and would, therefore, prove an adequate source for the barium of the barite, which they have brought from still deeper regions.

Clarke's tables of rock-analyses⁸ give averages of from 0.04 to 0.06 per cent. of barium oxide for shales, sandstones, and igneous rocks, and the analyses of two groups of samples of limestones showed no barium at all. Since even the Potosi limestone has only less than 0.005 per cent. of barium sulphate, one would expect that, according to the descension hypothesis, barite should be most abundantly present in fissures or replaceable limestone in shale- and sandstone-districts, which have been subjected to long periods of weathering. It seems best to assume, therefore, that the calcium and magnesium carbonate in which the barite is generally found simply serves as a precipitating-agent in which cavities could be easily formed.

All of the quartz in Washington county is older than the barite. The best explanation of this obvious quartz-cementation requires alternations in the flow of the water. In the downward course it dissolves some of that quartz which is combined with soluble bases, and while slowly rising it deposits quartz from cooling solutions of silicic acid. Some barite, if enough were present, would naturally have been deposited in the small vugs or as concretions in the limestone at one or the other of these stages, for alternate slight solution and deposition always make large minerals grow at the expense of small ones of the same sort. This growth is also due to the greater solubility of smaller particles.

All the barite is deposited in the larger or more continuous openings. In a general circulation, according to Van Hise, these are channels of rising currents. At any rate, they are the channels of rapid movement. At a time of elevation of the land, the rapid movement would be downwards, but the solution could not then become saturated with barite at the surface, and there are no signs of the deposition of the barite in caves whose walls were being dissolved, a result which would be noticeable on the backs of barite sheaves. At a time of depression, stored solutions would flow rapidly upwards and finally into old caves, etc. This is clearly the stage in which the barite was de-

⁸ *Bulletin No. 168, U. S. Geological Survey (1900).*

posited. (The solution may have received its barite in the belt of weathering, but its saturation would then indicate stagnation below.)

In Franklin county, just north, are many definite veins of galena and barite in fault-fissures. At the Virginia mine⁹ a fault striking N. 20° W., carrying usually from 18 to 24 in. of barite undiminished below, was opened to a depth of 480 ft. and a length of 1 mile. Here is, therefore, at least one fissure which undoubtedly extends to sufficient depth to reach the igneous rocks. There are many other faults, probably also deep.

In Tennessee there are single fissures, and especially groups of intersecting fissures, in which there has been much metasomatic replacement of the walls. Until more work has been done upon the conditions of solubility of barite, it is unreasonable to suppose that solutions saturated with barite in the belt of weathering could descend through dolomite all the way, and at greater depth be able to dissolve more dolomite and precipitate barite in its place. It may, therefore, be concluded that these fracture-zones extend to a deep source of barite. In Missouri, the amount of denudation has been but a fraction of that in the Tennessee valley, especially if that accomplished previous to the deposition of the quartz be deducted. Therefore, in Missouri the tops of the barite-veins are found, while in Tennessee the bottoms are seen. The differences are similar to those between the tops and bottoms of gold-veins. The similar Washington county fracture-zones probably, therefore, extend to equal depths.

The difficulty of the metasomatic replacement of a rock by a totally different chemical compound and by solutions already saturated with the same rock-constituents by a long downward course through the rock, applies with even greater force to the Flat River lead-ores, which generally replace the country-rock most abundantly in the dolomite stratum nearest the Archæan rocks beneath.

The barite stalactites at Morrilton, and others mentioned by Winslow as occurring in Franklin county, have clearly been formed by descending solutions, but these may have obtained

⁹ *Report of the Missouri Geological Survey*, vol. vii., p. 696 (1894).

their barite from the weathering of earlier veins filled from below. The stalactites were afterwards coated with perfect tabular crystals. Since all the barite crystals of Washington county are of the crested type, and the massive barite is not stalactitic, it is quite apparent that the Washington county barite was deposited under different conditions, though not necessarily, therefore, by rising solutions.

Most of the barite of Missouri at all stages of deposition is contemporaneous with more or less galena, which has the same order of solubility. It is seldom, if ever, contemporaneous with calcite, and rarely with dolomite. This indicates a separate source or time of solution of the carbonates and the barite. The carbonates in Washington county would naturally come from the zone of solution.

In Kentucky, the barite is contemporaneous with white calcite, but there it is also clearly contemporaneous with fluorite, and obviously in fissure-veins derived from below, and associated with igneous dikes (0.06 per cent. of barium oxide, BaO).

Van Hise¹⁰ says that fluorite weathers to calcite. Therefore the presence of a little fluorite in the barite of the Knox dolomite and of much fluorite in the barite of Caldwell county, Ky., proves that the veins in these carbonate-regions were filled by solutions from below. Unfortunately, no especial search was made for fluorite in the barite of Missouri, because this association in the other regions was not known to me at the time the field-work was done. It is certainly not common. I have observed argentiferous galena in a gangue of massive barite of Missouri type, filling fissure-veins in granite and porphyry, in the White mountains of New Mexico. The walls of these veins had been extensively altered to sericite, and they were obviously filled from below. Similar instances of barite coming from below and quoted in the literature could be multiplied almost indefinitely. Thus there is nothing strange about the process.

The same dolomite covers a wide area of Missouri. In many places it seems to lack an excess of unfilled caves and fissures, but in Washington county at least there are a great many of even the oldest quartz-lined openings entirely without barite.

¹⁰ *Treatise on Metamorphism*, p. 373 (1904).

Still, the barite occurs in decidedly limited patches, often long and narrow. One man's field may yield 2,500 tons of barite per acre from the residual soil, while another just across the road will have practically no barite. This seems to be the most decisive proof that the barite came in through fissure-zones from below, rather than from the uniform dolomite present everywhere.

Much barite and galena are now disintegrating in the residual soil, and some barite doubtless goes into solution and is precipitated immediately below. This probably accounts for the apparent present continuance of the formation of barite crystals. Barite is soluble to the extent of from 23 to 40 parts in 10,000,000 parts of water, depending upon its fineness. It is, however, somewhat readily soluble in strong solutions of carbonates in the presence of carbonic acid. Its solubility under these conditions increases rapidly as the pressure of carbon dioxide increases, which would tend to prevent the precipitation of barite from descending solutions. The influence of the increasing amount of magnesium carbonate presents an unknown factor which makes chemical speculations idle. Barite, however, does not suffer solution by oxidation at the surface and precipitation by reduction below the zone of solution, as does galena.

The evidence, therefore, seems conclusive that the barite originally came from below. The barite-bearing granites and porphyries of Archæan age are not very deeply buried in Washington county, so the faults certainly extend down into them and they afford a convenient source. In pre-Algonkian time these rocks were greatly affected by solutions, and the visible barite may have been then concentrated or brought in from the basic dikes intrusive in them.

Since all the igneous rocks suffered a long period of weathering before the Cambrian and later sediments were put down, magmatic water, etc., could have had no immediate part in the introduction of the barite, which with the Washington and Franklin county galena must then have been brought up by rising trunk-currents of the circulation of meteoric water, some of which fell upon the igneous rocks of the St. Francois mountains, which were always free from Palæozoic rocks and higher than the Washington county sea- or land-level.

5. *Present Condition of the Barite.*—As the dolomite became dissolved the barite accumulated with the clay, flint, and other residual material. Commonly the barite is somewhat concentrated at a depth of from 2 to 6 ft., probably the lower limit of the disturbance of the soil by frost and other agencies. Above this, the clay contains an unusual amount of flint or chert uniformly scattered through it.

Beneath the first bed of barite the clay seems more undisturbed and the barite is scattered irregularly through it. Most of the slabs of barite have fallen over and are now horizontal, and there is likely to be a little more barite immediately above the bed-rock. The upper part of the weathered dolomite is soft and crumbly and is often called sandstone. Some of the larger slabs of barite are dug from this until it becomes too hard. Near the bed-rock the barite is quite hard, more nearly translucent, and contains iron-stains only upon the surface.

Near the surface the barite is commonly not much softened, but thin layers of limonite are deposited in the cleavage-planes, along which the barite breaks up. When very dark and purplish this barite is sold at half price as No. 2, or "battle ax," on account of the difficulty of bleaching it. There is a little which is deep yellow all through. It was said that this stain was not due to iron and could not be removed by sulphuric acid in the bleaching-process, even by those mills which grind before they bleach. It cannot therefore be sold. Laboratory-tests show that the stain is only iron and clay, and perfectly soluble in rather strong sulphuric acid. Frequently, quite a lot of barite of walnut-size is found near the bottom of the flint-zone.

In places the lumps of barite adhere to a good deal of chert which probably once projected from the walls of the caves. Upon other specimens are shells of hard, dark limonite, called "metallic iron," and representing weathered marcasite. Both the flint and the iron can be chopped off with a hatchet. The quartz crusts, called "mineral blossom," are so irregular and so frequently included in the barite that they cannot be chopped off, and reduce the grade to No. 2, because the resulting grit is especially objectionable in the barite floated for pigment. Where there is much mineral blossom the barite is therefore not mined. A little barite which probably once contained

strontium sulphate is now very soft and dazzlingly white. It is sticky in the grinding-mills and cannot be sold.

In each particular locality the miners have more or less reasonable theories as to the occurrence of the barite along certain leads. At Bliss there certainly are long straight bands of barite running NW. and representing old cave-fillings. These bands are only from 20 to 50 ft. apart, or closer than the caves, due to the great vertical concentration caused by the solution of the limestone. In most places the barite seems to have been derived from groups of caves or fissures, and it is rather uniformly distributed, though often irregular, crooked, richer streaks can be followed through the elongated patches. The method of mining by rows of pits usually accounts for the idea of leads. There is also no uniform ratio between the amounts of barite and of galena, for some of the best barite-patches yield very little galena, and *vice versâ*.

II. THE MINING INDUSTRY.

1. *Amount of Barite Available and the Output.*—The entire area is very irregularly supplied with barite, which is commonly mined in patches from 10 to 15 acres in size. The longest single patch is at Mineral Point, where the crest of a low ridge has been mined almost continuously from 50 to 300 ft. wide for a distance of half a mile. The barite, or "tiff," as it is called by the miners, is mostly mined from cleared farm-fields, which showed a little barite upon plowing and were accordingly prospected. The patches are therefore most frequently upon the slopes of the hill-sides, where the barite is likely to be exposed. There are probably several good patches in the woods which have not yet been found, although the country has been prospected for more than a century.

James Long, of Potosi, the largest and oldest shipper of barite, estimates that of the entire area of about 100 sq. miles, one-tenth is workable barite-land. The best fields have produced from 2,500 to 4,000 tons, which is probably only about one-half the barite they contain. The average field, under the present system of mining, yields about 600 tons per acre to a depth of 8 ft., or about 100 lb. per cubic yard, but it takes many years to produce this amount, and very few fields have been anything like exhausted as yet. Upon this basis of estimate,

the probable total yield, without a change in mining-methods, will be about 4,000,000 tons, or more than a century's supply, if we count new discoveries equivalent to the amount already taken out.

Every little country store accepts barite in exchange for supplies, but it is all shipped through half a dozen contractors. The total amount shipped was given as 33,046 tons. Nearly all of this was first-class barite, and sold for \$4.35 per ton at the shipping-point, or \$5 at St. Louis. In 1905, the price was reduced to \$4.10, at which it now stands. The royalty to the owner of the land is quite uniformly 50 cents per ton, but is 80 cents on one especially good field, and as low as 15 cents when very far from the railroad. The miners get as much as \$2.75 a ton when much cleaning is necessary, but usually from \$2.20 to \$2.50, and only \$1 a ton at Richwoods, from which the wagon-haul costs \$2.50. The haul usually costs from 25 to 50 cents a ton, and the contractor gets the rest. Farm-land containing barite in some of the fields sells at \$35 an acre, which is not much different from its farming-value. Wild land, from which the best timber has been cut, is worth only from \$2 to \$8 an acre. Some land next to the railroad-siding, and all containing a little barite, was bought at \$60 per acre. One 10-acre field near Potosi has yielded a royalty of \$200 per acre each year for 10 years, and a neighboring field, which is supposed to be just as good, is still farmed and held in reserve. About 400 miners are supported wholly by the barite industry, besides those engaged in hauling, etc. So far as I could ascertain, these men do practically no farming, although it is so stated in the books.

2. *Mining-Operations.*—A little barite is still produced from mines extending below water-level into bed-rock, but only when associated with enough lead to pay expenses. The small scale of this work and the inexpensive plant form a striking contrast to the great mines at Flat River, a few miles east. Each shaft usually follows a vertical fissure until a cave is reached, when a drift only 3.5 or 4 ft. high is driven along the little horizontal stringer of galena and barite, which is commonly less than 6 in. thick and carries about 25 per cent. of lead. Deposits having a cave above or below are naturally preferred, since the cost of blasting is reduced, and in addition

large crystals of galena frequently occur upon the surface, from which they are easily cobbled off. The little ore-streaks are followed as long as they nearly pay expenses, since they sometimes lead to large and profitable bodies of ore.

Most of the barite is dug from the residual clay. The common plan is to sink a pit, 3 ft. in diameter, to a depth of from 6 to 9 ft., to the first lean clay below the upper barite-layer. The miner then selects the richest side of the shaft, which he digs out beneath the upper clay, which is rather barren for from 3 to 6 ft. below the surface. In this way he "drifts" as far as he thinks is safe, usually from 4 to 8 ft. Up to this stage all of the clay, flint, and barite loosened is hoisted in a small bucket by a primitive hand-windlass; but the miner usually sorts out the barite, which he recognizes from flint only by its greater weight, since it is completely covered with tough red clay. When the first drift is finished all the waste from the new drifts is shoveled into it, and the miner digs other drifts wherever the ground looks good, so that the working soon resembles an inverted mushroom.

When the first hole is finished, another is started in the direction that looks best, at such a distance that the safe drift backward will just connect with the old workings and give a little ventilation. The second hole is exhausted as before and a third one dug beyond. This plan produces a more or less regular row of pits, and gives rise to the theory of leads. When a lean place is struck the lead is said to have given out, and another row of holes is started, until finally they are scattered over an old field like the squares of a checker-board, and perhaps one-half of the barite is removed.

I have heard of no accident attending the mining, and since many of these holes remain open for years, in spite of the rain, it seems probable that the length of the drift is not limited by safety, but rather by the distance reached by daylight, and the greater convenience of working near the shaft, which about balances the labor of sinking a new pit with the ordinary amount of covering. Owing to the tendency to imitate, the size is the same whether there is 2 ft. or 6 ft. of barren cover.

When the upper layer of barite has been exhausted, or the field is very rich, the pits are sunk deeper. In summer, when

the ground is cooler than the air, the ventilation is poor, so that the pits are seldom deeper than from 15 to 18 ft. In winter they go to bed-rock, or sometimes more than 30 ft. These deeper pits are often worked like the others. The more intelligent miners generally drive drifts from 4 to 6 ft. high for 8 or 10 ft. in three directions, as shown in Fig. 2, and connect the ends so as to leave pillars. The roof is then caved or stoped upwards and the waste left on the floor. As the space fills up and the old workings are approached the area is de-

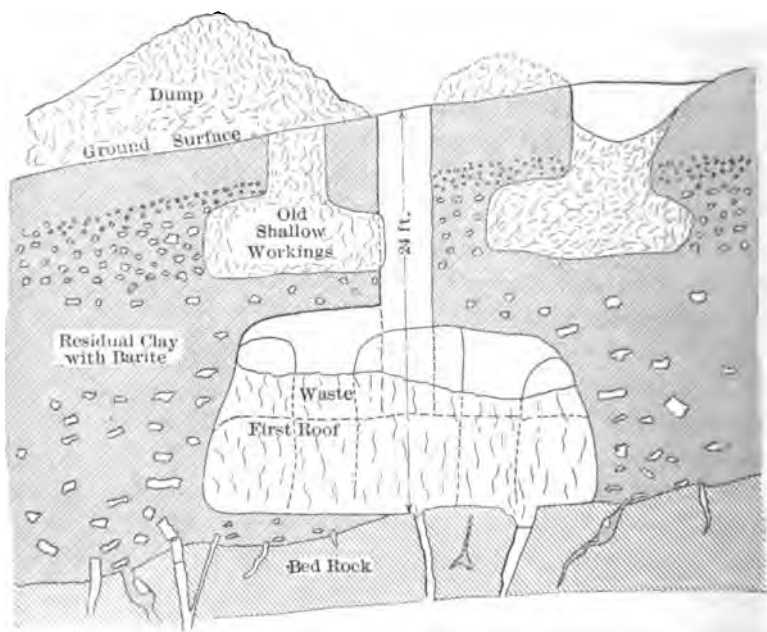


FIG. 2.—CROSS-SECTION OF DEEPER BARITE-WORKINGS.

creased. The new pit is sunk so close to the last forward drift that but little drifting is required to make the air-connection. The connection-drift is often stoped from the second shaft. By careful work four-fifths of the area covered by the row of workings can be mined; but since the drifts are stoped wherever the ground looks poor, and the pillars are larger than the drifts, and the stopes decrease in size upwards, more than one-half or two-thirds of the ground is seldom mined. Since one row of pits is driven without regard to the others, and a good deal of pillar must be left between rows, at best only a small percent-

age of the barite is recovered. Indeed, so much is left that I saw no field of pits which was said to be worked out.

As the price paid for mining increases, men will dig around among the old workings, in spite of the annoyance of striking old drifts, even where the pits have been sunk to bed-rock. This shows that much barite is lost between the pits. There is also a loss due to the irregularities in the surface of the bed-rock and the caving-in of unfinished holes by rain. Since the miner leaves the poorer parts, the loss of barite is not as great as the percentage of ground unworked. In a field rather carefully worked to bed-rock it was roughly estimated that half the barite was lost.

While one man digs the barite, his partner or wife stays on top to work the windlass, and with a small tomahawk-shaped hatchet cleans the barite of the clay, the worst iron-stain, and any flint that may adhere to it. In summer a rough sun-shade of branches is built.

Most of the clean barite is in lumps, weighing from 3 lb. (large fist-size) to 20 lb., and the finer stuff is thrown away, except near the railroad. Here the small pieces at the top of the barite-layer are piled upon the ground, where the weather loosens some of the clay. This barite is later cleaned in a tumbling-barrel or "rattle-box," and shipped as second grade on account of the larger amount of iron-stain upon it. The rattle-box, shown in Fig. 3, is a strong box, 18 by 30 in. by 10 in. deep, with a slat bottom and the ends thickly studded with strong spikes driven through from the outside. On the sides are uprights of 2- by 4-in. pieces, forming legs 1 ft. long and handles 3 ft. long. From 100 to 150 lb. of small and thoroughly dried barite is shoveled into the box, which is then rocked upon the feet by two men. When the end of the box strikes the ground, the barite is thrown forcibly against the spikes until all the clay is knocked off and falls through the slats.

The miners receive from \$1.60 to \$2.75 per ton for cleaned barite, and by working 6 hr. per day a pair will usually earn from \$6 to \$7 in 5 days. Since they can live a week upon this amount, they seldom earn more than \$8 in a single week, and when a rich spot is struck they spend the time loafing and drinking up the excess earnings. When the ground is lean they work longer.

The miners are usually the most ignorant "gumbo French," and speak no language but their own French dialect, and therefore resist any change in the system of mining. Their scheme has the advantage of all "gopher" mining, that the minimum of barren material need be handled. When the over-burden is thick, this method is probably as good as any, if controlled by an efficient superintendent who would see that the pits are regularly spaced, except where there are real leads. The drifts could generally be higher and longer with advantage.

The Point Mining & Milling Co. installed a pneumatic cleaning-pick and a mechanical washer, and tried to buy uncleaned barite at a lower price. By having one top-man for

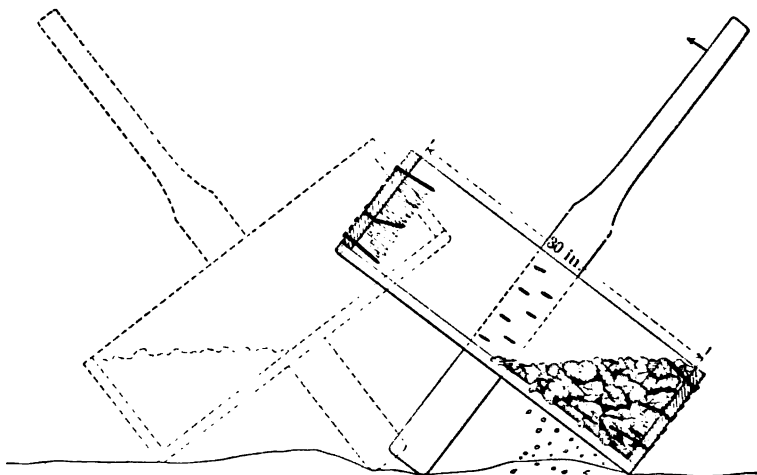


FIG. 3.—"RATTLE-BOX" FOR CLEANING FINE BARITE.

two diggers, the miners earned more money upon this basis; but they did not want to work in threes, and, according to the old arrangement, the top-man has plenty of time to clean the barite. Therefore this machinery is not now used.

Some of the better farming-land will not be released for barite-mining, since the pits and dumps ruin the land. Occasionally the top layer of barite in a small field is mined out rapidly and more systematically, and the miners are required to put the waste material into the pit immediately behind. When the larger stones are put in first, this mining improves the land.

In two or three cases fields having but little stripping were

mined by advancing a trench 6 ft. deep across them sidewise. This method gives much better recovery, and affords a good opportunity of placing the best soil on top, and would be used oftener, except that it is hard to get the miners to work for day's pay, and constant supervision is required.

One large company, now bankrupt, wasted a good deal of money upon a traction-engine and wooden-rail tramways for hauling, in competition with the Missouri mule in his own home. At the time of my visit uncleaned barite was mined by day-labor, the clay washed off in a patented trommel-washer, and then the iron and flint chopped off by hand. This system gave a considerable saving, even though the work was inefficiently managed. A little saving was probably due to the greater richness of the newly-opened field, but the method is hopeful.

At the Duffy farm a big company undertook to work the barite hydraulically. The exact arrangement of the sluices could not be determined. On the gentle hill-side above the reservoir is a pit 40 by 80 ft. and about 10 ft. deep to bed-rock. Everything seems to have been well constructed, but the method soon failed for lack of water and of fall to remove the tailings. A little trouble also arose from the depressions in the bed-rock. There are but few places in this field where there will not be trouble with tailings. So it is apparently better to abandon sluices, hydraulic the material over a grizzly, pick out the barite, and remove the tailings by some sort of elevator. The tough clay is hard to handle by water, and labor is so cheap that labor-saving machinery may not pay.

The engineer of the Point Mining & Milling Co. was thinking of mining the residual soil with a steam-shovel, running it through a trommel to shake loose the clay, and carrying the refuse to the dump by belt-conveyer, from which the barite should be picked by hand. This system would be especially adapted to the thicker level deposits. The daily output would be very great, and a large crew of pickers would have to be organized, and there would be some expense in handling the tailings. Since much of the land will yield from 125 to 250 lb. of barite per cubic yard of soil, and the cost of mining uncleaned barite by present methods is about \$1.50 per ton, this system shows a margin of from 10 to 20 cents per cubic yard for handling by steam-shovel, which is not especially attractive. In

localities where water is available, it might be better to treat the soil in a modified log-washer, and pick out the partly-cleaned barite.

In most places the best method of mining seems to be to strip the barren cover with plows and scrapers, and mine the rest with pick and shovel, as is done in Tennessee and in central Missouri, where the deposits are smaller and richer. It had not been tried in Washington county previous to 1905.

III. PREPARATION FOR THE MARKET.

1. *The Barite-Mill at Mineral Point.*—Previous to 1905 most of the barite of Missouri was prepared in the mill of Nulsen, Klein & Krausse, and some by J. C. Fink Mineral & Milling Co., both of St. Louis. The former has a department for making floated barite, resembling that of the new mill at Mineral Point, but a second-grade pigment is also made from unbleached selected barite. These mills are not in Washington county, and it seems better to omit a discussion of them, since they are similar to the many other mills which have been previously described.

During 1904 the Point Mining & Milling Co. invested about \$150,000 for barite-land and what is claimed to be the largest wet-process mill in the United States. Its capacity is about 35 tons of finished product per 24 hr., or, allowing for delays, about 10,000 tons per-year. The mill was designed by W. R. Macklind, who has kindly given me the following data.

A diagram of the operations at this mill is given in Fig. 4.

The barite is weighed upon a platform-scale and shoveled into the ore-house, which has a horizontal air-drill with chisel point for cleaning the flint and iron from the barite when this is not done by the miners.

From the ore-house the barite is shoveled into an 11- by 16-in. Blake breaker below the floor, which reduces it to pieces of 1-in. size. It is then elevated to a 30-ton bin at the top of the room, whence it is taken to three modified log-washers in series, in which nearly all of the clay is removed.

The washed barite is wheeled across the floor to two Macklind "slip"-mills or modified *arrastres*, through which a large stream of water flows, and floats the fine barite over the edge of the pan. This milky water is raised to the top of the mill

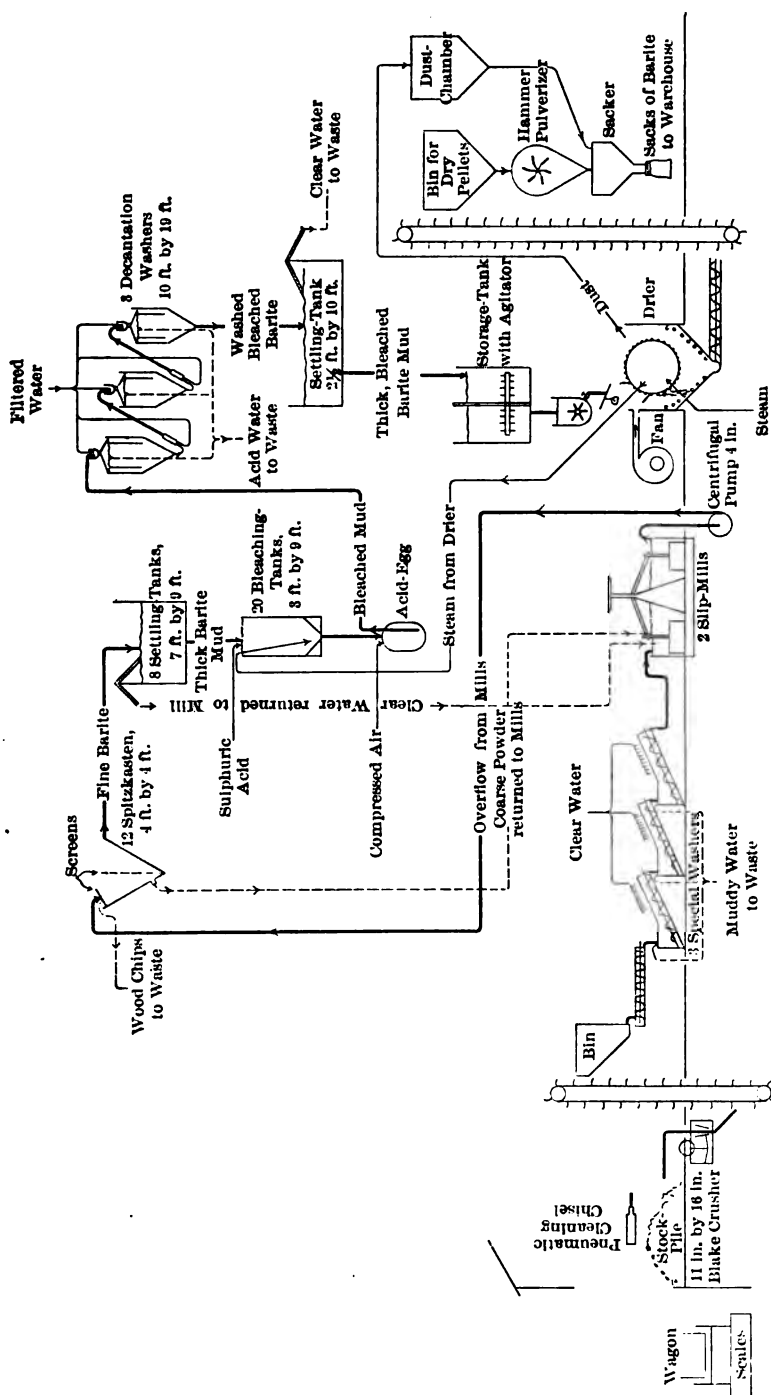


FIG. 4.—DIAGRAM SHOWING THE PREPARATION OF BARITE IN THE MILL OF THE POINT MINING & MILLING CO., MINERAL POINT, MO.

by a 4-in. centrifugal pump, and fed through a small screen into 12 iron *spitzkasten*, 4 by 4 ft. in size. The oversize is drawn off through spigots at the bottom of each box and returned to the slip-mills. The fine barite overflows opposite the entering stream into one of 8 settling-tanks, 7 by 9 ft. in size. The clear water is siphoned from these tanks and returned to the slip-mill. The thick cream-colored barite mud, which contains but 25 per cent. of water, is drawn off through 4-in. plug-valves and a rubber hose to one of 20 bleaching-tanks on the floor below.

The required amount of 66 per cent. sulphuric acid is added, and the mass agitated and kept at the boiling-point by a jet of steam introduced through a lead pipe. When the barite becomes white it is drawn off through a plug-valve in the bottom, and raised by an acid-egg to the first of three Macklind continuous decantation-washers, in which nearly all of the free acid is removed. From the bottom of the last washer the barite is drawn off to one of two settling-tanks, 2.5 ft. deep and 10 ft. in diameter. Here as much clear water as possible is siphoned off, and the barite let down into a storage-tank provided with an agitator to keep the barite mobile, since it contains but 15 per cent. of water.

From the storage-tank the barite flows to a Macklind continuous automatic drier. A screw-conveyor collects the pellets of barite below the drier and delivers them to a belt-elevator supplying a bin above a Williams hammer-mill which pulverizes these pellets. The product is packed in 100-lb. duck sacks, and stored in a warehouse of 3,000 tons capacity.

The mill is driven by an 18- by 36-in. 200-h.p. Fulton-Corliss engine, running at 75 rev. per min., and supplied with steam at 100 lb. per sq. in. pressure, by two 72-in. by 18-ft. return-tubular boilers. There are a feed-water heater, duplicate feed-pumps, etc. A 35-kw. direct-connected Westinghouse unit supplies current for lighting the mill, and a Curtiss belt-driven compressor supplies the compressed air.

Besides the superintendent and office-man, there are 12 laborers at \$1.50 a day on the two shifts, two slip-mill men at \$2, one bleacher at \$2, two engineers at \$2.50, and two firemen at \$1.75, all working 12-hr. shifts. At the time of my visit the mill had not been operated long enough to get reli-

able data of costs, and details of operation were being constantly improved. The cost of manufacture is somewhat high.

Much of the machinery is standard and need not be described. Each unit of the washer consists of a 12-in. screw-conveyor, 10 ft. long, inclined at an angle of 20°. The housing of the conveyor is arranged to hold the water-level high enough to cover two-thirds of the length of the screw. Above this the barite, while being stirred by the screw, is sprayed with about 25 jets of water, $\frac{1}{8}$ in. in size, under a 45-ft. head. The edge of the screw-conveyor has a V-shaped notch, 1.5 in. deep, every 4 in., which allows a larger part of the fine material containing the most clay to flow back again and be rewashed. At the lower end of the conveyor a strong jet of water washes the mud and a little of the finest barite over the edge of the housing. The barite is fed upon the lower end of the first conveyor and discharged from the top of the last one. These washers have a capacity of about 120 tons of barite in 24 hr., and consequently are not operated continuously. Each unit requires about 40 gal. of water per minute.

The slip-mills were designed and patented by Mr. Macklind. Briefly, each mill consists of a tub of steel, 10 ft. in diameter and 3 ft. high, which is paved with carefully-cut blocks of Missouri granite. Over this pavement are dragged four granite blocks, roughly triangular, 36 in. on a side and 18 in. thick when new. There is a 3-in. bevel on the bottom along each edge. A heavy three-armed cap is clamped to the top. This cap has four holes about 6 in. apart along the leading side, and the dragging-arm is frequently changed from one to the other of these to change the direction of the drag and prevent corrugations in the bottom of the stone. Once in about 60 days the cap is loosened and the stone turned to present another leading-edge, which makes it wear evenly. At such times the bottom of the stone is usually roughened slightly. The stone should last for three years, but the wear on the bottom of the mill is about twice as rapid, and is, of course, greatest at the periphery. About once in two years the bottom will have to be raised or renewed.

Among the new features of this mill are an unusually heavy spider, and an arrangement of a weight and lever like a safety-valve, by which any fraction of the weight of the spider can

be transferred to the stones. This is adjusted to suit the different grades of barite. The weight-pin can also be lengthened to allow for the wear of the stone. The rest of the weight of the spider is carried upon a ball-bearing toe-piece raised above the water.

In the old-style mills trouble was caused by the tendency of the charge to form a self-supporting ring between the stones, which would then rub upon the bottom and wear more rapidly, and even at times break the gear or spider on account of the rapidly-increasing load. In this case the mill had to be stopped and the ring laboriously broken by hand. Mr. Macklind corrected this difficulty by providing the main-shaft with a ball-bearing collar, which can be raised 6 in. by a steam- or compressed-air piston. This also raises the stones, and the water soon causes the ring to collapse. It seems that this difficulty would be avoided if the distance between the stones were made greater by decreasing their number or increasing the diameter of the mills, according to the Mexican style. Mr. Macklind's scheme, however, has the incidental advantage that when the stones are raised the spider can be easily revolved by hand for inspection or repairs or for cleaning out the mill. In starting up it can also be brought to its normal speed of 20 rev. per min. by hand, so a simple positive clutch can be used on the gear.

When the mill is grinding properly, the stones tremble or chatter noticeably and the gearing runs without noise. When one of the stones begins to rub on the bottom the groaning of the gear should be immediately noticed by the attendant, who then raises the spider for a moment. The mills should have about 8 in. of barite in the bottom, and the attendant sounds them with a rod to determine the need of more feed, but of course soon learns how rapidly to shovel in the barite. At 20 rev. per min. each mill has a capacity of from 15 to 18 tons per 24 hr., but generally 12 or 13 tons is ground, and this output determines the capacity of the entire plant. About 15 h.p. is required for each mill.

The water flows through this mill at the rate of 100,000 gal. per 24 hr. This large stream of water may be necessary to provide for an increase in the capacity of the mill, but since more than 40 h.p. is required to raise the water 45 ft. to the

separating-tanks, it does not seem to be as economical as increasing the number of mills. The number of *spitzkasten* was increased in order that the floated barite should be fine enough. It is said that this fine barite was examined with a microscope, and the largest pieces were small enough to go through a 300-mesh sieve. The stream is divided equally among all the boxes, and enters through a fine screen to reduce the agitation. This screen also removes a few small pellets of clay and chips of wood. There is also a vertical screen in the middle of the box to prevent the formation of eddies.

The bleaching-tanks are lined with three lengths of 36-in. sewer-pipe without bells, and four special tiles form a cone-shaped bottom. They are made water-proof by an 8-lb. hard-lead covering on the outside. The hydrostatic pressure is resisted by oak staves and iron hoops outside the lead. The tanks are charged with 2 tons of settled barite, containing 25 per cent. of water, and a minimum of 240 lb. of 66 per cent. sulphuric acid is added. The acid is received in tank-cars, and costs a cent a pound. It is run into a large steel storage-tank, from which it is pumped by an acid-egg to an elevated lead-lined tank; thence it flows through lead pipes and valves to the bleaching-room on a level with the top of the bleaching-tanks. Here it is handled and measured in a small lead-lined tank-car. After the acid is added, steam is run into the bottom of the tank to agitate the mass and heat it to nearly the boiling-point. At first, lead-lined iron agitators were used, but they wore out very rapidly. The tile lining of the tanks protects the lead from all mechanical wear, and it soon becomes coated with lead sulphate.

It requires about 45 min. to heat the mixture, and the best quality of ore can be bleached in from 6 to 7 hr.; but since there is plenty of tank-capacity, the bleaching is always continued 12 hr. or more. If the bleaching is not finished in 12 hr., more acid is added; but it is unsafe to reduce the amount below 120 lb. per ton, on account of uncertainties as to the ore. No attempt is made to save the unused acid. To tell when the bleaching is complete, a 2-oz. bottle, full of barite, is compared as to color with a standard sample.

The bleached barite is drawn off through lead-covered plug-valves in the bottom. The handling of this hot, thick, heavy,

and corrosive material has proved very troublesome. It has been most successfully pumped to the washing-tanks by a very heavy acid-egg.

These washers, Fig. 5, designed by Mr. Macklind, consist of lead-lined iron tanks, 10 ft. in diameter, 19 ft. high, having a cone-shaped bottom. In a lead cup above the center of the tank the bleached mud is mixed with a strong jet of water, and then distributed by a flat lead cone to the circumference of the tank and discharged upon baffle-plates. In the center of the tank is

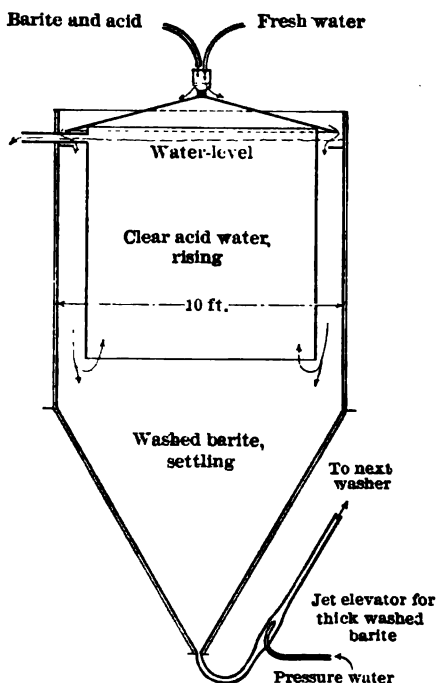


FIG. 5.—MACKLIND CONTINUOUS BARITE-WASHER.

a bottomless lead cylinder, 8 by 8 ft., inside of which the water rises so slowly that all the barite settles out, and only clear acid water is discharged to waste through a lead pipe at the surface.

From the bottom of the first washer the barite passes to a similar one 3 ft. lower. From this it goes to a third one still lower. Since, with this head, the heavy, settled barite would not flow from the bottom of one tank to the top of the next,

the current is maintained by a strong jet of wash-water directed upwards in the discharge pipe. (A similar arrangement might be serviceable in elevating the thick barite from the bleaching-tanks.)

All the acid should not be removed or the barite will immediately turn a light yellow; the end-point used to be determined by a slight acid taste, but the washing is now continued until there is no taste, but the iron sulphate remaining in solution will give a slight blue color with potassium ferrocyanide, thrown upon the last spreading-cone. When this does not show, the quantity of wash-water is reduced. The reason for the change of color when no acid is present is not understood. This acid prevents the use of floated barite for weighting rubber and paper, but for paint it is not objectionable. If the settled barite mud at the bottom of the washer has 50 per cent. of water, this leaves about $\frac{1}{3}$ lb. of acid to the ton of barite; if it has 100 per cent., which is more likely, 1 lb. to the ton will be left.

The wash-water is filtered through six sand-filters, 36 by 60 in., and is obtained from a small creek by a separate pump. The general mill-supply is filtered only when very muddy.

The essential part of the Macklind drier is a cylinder of wrought-iron pipe, 36 in. in diameter and 8 ft. long, revolving one-and-a-half times per minute, and heated inside by live steam. Upon this cylinder the barite is dropped by a plate shaken 200 times per minute by a cam. The thick, settled barite mud is fed upon the shaker-plate in fine streams 4 in. apart through pin-valves from the feed-trough, which contains an agitator to prevent packing. The drops of barite falling upon the hot drum are soon dried and are scraped off by a plate after nearly a full revolution. This scraper leaves a thin layer of strongly-adhering barite, which prevents discoloration from the iron. The live steam enters through a stuffing-box at one end, and the condensed water is drawn off through a siphon-pipe in the other trunnion and circulates through coils along the side of the housing, and drips whatever barite is spattered off by the boiling pellets.

To prevent the accumulation of air in the cylinder, some steam is drawn off through a straight pipe entering through the siphon and carried to the bleaching-tanks.

The finished barite is tested for color by putting a spatula-

full upon a glass plate beside a standard sample, smoothing it down beneath a piece of paper, and comparing as to color. It is then moistened with turpentine and again compared. In this way it shows as white as a standard sample of white-lead, which had a slight buff color, but not as white as good zinc oxide, which is blue in comparison. The product is tested for grit by rubbing it with a spatula upon soft glazed paper, which should not be scratched. Barite which contains flint will be apt to show more grit when floated, since the equal-falling grain of quartz is so much larger than the heavy barite. Barite ground between burr-stones gets grit from the mills. In the wet-process mill, in which the barite is ground before bleaching, hard iron or steel could be used in the mill and the pigment would be entirely free from grit if the barite contained no quartz.

Barite, on account of its prismatic cleavage, forms a "sliver" pigment rather than a granular one. These slivers mat together in the paint, and since barite is slightly harder than the other pigments, it forms a more durable paint. It is also entirely unaffected by weather, and does not dissolve like zinc, or blacken with sulphur like lead.

White-lead is said to saponify linseed oil. At any rate, after a few years, a pure white-lead paint will chalk and rub off, leaving the surface in good shape for a second painting. So far as known, zinc is not used alone, but if the paint contains too much barite it peels off and a second coat of paint will not stick. The mixture of white-lead and barite pigments is therefore better than either one alone. Some of the peeling may be due to inferior oil.

When barite is sufficiently ground it will spread well. The chief objection to it is its translucency and lack of covering-power. This deficiency is best corrected by zinc oxide, which has the greatest covering-power. Some of the paint-men therefore say that an equal proportion of the three pigments makes the best paint. The unfortunate feature is that usually good barite costs less than a cent a pound, while the other pigments cost 6 or 7 cents, so that much of the prepared paints contain too great a proportion of barite, up to 60 per cent.

Very little barite is now used in making fine book-paper, since the weight of a book is no longer considered an advan-

tage, and fibrous talc is used instead. Its use in rubber goods seems to be a trade secret.

For making barium salts a very inferior barite can be used, but most of this chemical manufacturing work is done in Europe. There would be a big demand for barium oxide for treating boiler-water containing much calcium and magnesium sulphates, but it is not yet supplied cheaply enough in the United States.

I desire to express my cordial thanks for information regarding Washington county barite to W. R. Macklind, of Mineral Point; James Long and James W. Richeson, of Potosi; Frank Long, of Cadet; and Robert McClay, of Bliss, Mo.

The Genesis of the Leadville Ore-Deposits.

BY MAX BOEHMER, DENVER, COLO.

(Pittsburg Meeting, March, 1910.)

AFTER 30 years of development and after an output of \$350,000,000 in value of gold, silver, lead, zinc, and copper, there has not been published a satisfactory explanation of the origin of the immense deposits of the Leadville district.

The original examination and survey of Leadville by members of the U. S. Geological Survey was a most magnificent piece of work, but their attempt to explain the origin of the ores was based upon the then-accepted theory of lateral secretion, originated by Sandberger, which theory was afterwards disproved in many cases by further development in numerous districts.

This theory contended that the ore in the veins had been leached by surface-waters from the eruptive rocks in the immediate vicinity, and it had its origin in the fact that the neighboring eruptive rocks all contained, to an appreciable degree, the several metals found in the ore-deposits.

But the practical miner, reasoning in a simple manner from the condition of things as he found them underground, soon discovered the fallacy of this proposition. He reasoned that, in the case of the Leadville deposits, this theory could not be true, because, if the ores were leached from the overlying eruptive rocks by surface-waters, they would as a matter of necessity be controlled by the action of gravity, and the main bodies would collect in natural depressions of the underlying limestone, and at all points where such depressions existed. But this was not in accord with the channels of ore as he found them; and hence the theory of lateral secretion in this district was never accepted. Another objection to it consisted in the fact that large areas within the ore-bearing district contained no ores whatever, although their formation was the same, and the same limestones were covered by the same thick sheet of

eruptive rocks. The experts of the Geological Survey themselves soon saw that their original theory was not satisfactory, and it is expected that their later examination and survey of the district will throw a new and correct light upon the subject. But we do not know when this report will appear; and, meanwhile, others, who have given some thought to the subject, may be permitted to offer their ideas in the light of the latest developments.

That the eruptive rocks play a very important rôle in the genesis of most ore-deposits is now universally acknowledged. It seems also well established that the fluid magma of the eruptive rocks at great depth originally contained the metals which are found in the veins; that these metals were dissolved and segregated from the magma, then held in solution in depth, until pathways towards the surface were opened, when, under the influence of heat and pressure, the solutions rose in these pathways and deposited their burden wherever the conditions, either physical or chemical, were favorable.

In Leadville, it was discovered that the later eruptives, and not the earlier white porphyry, were the rocks most intimately associated with the position and trend of the ore-bodies; but mining developments did not give sufficient evidence upon which to base a plausible theory of the origin of the ores, since these later eruptives, as a rule, were found in the shape of sheets or irregular tongues and bosses. A few vertical dikes had been found, but they carried no ore on their flanks, nor was there a single ore-bearing fissure in evidence on Fryer, Carbonate, Rock, or Iron hills.

Breece hill also, in its earlier development, showed similar conditions. It is only the work done in the last five years on this latter hill which has at last, in my judgment, at least, solved the question and furnished the evidence upon which the genesis of the Leadville ore-deposits may be safely formulated. And this evidence is so plain that all should agree in the interpretation of the facts as lately disclosed.

The developments now show that the Leadville deposits have their origin in depth through the channels of fissure-veins and dikes of eruptive rock. Numerous fissure-veins, carrying valuable ores and generally associated with nearly vertical dikes, have been opened along the entire extent of Breece hill,

and beyond it for a distance of 3 miles. Their course is in all instances approximately N-S., and their dip is from 70° to 80° west or east. These fissures send out to the left and right large channels of ore into the adjacent stratified rocks, especially at the limestone horizon below the cover of the main sheet of white porphyry. This mineralization in the limestone extends at least a mile from the fissures, and the latter carry values down into the underlying granite.

In a number of cases, the fissure which admitted the dike-magma and later the vein-waters faulted the country; and it is important in exploitation to distinguish these pre-mineral faults from the later post-mineral faults which created the present topography of the country.

The veins accompanying these dikes generally lie along the foot-wall or the hanging-wall, but occasionally also within the body of the dike.

Frequently these dikes show no valuable ores associated with them, but a number carry along their flanks a mass of nearly clean quartz with scattered pyrites, which is probably not a segregation but an actual low-grade deposit, made by the vein-waters in the form of silicified country-rock.

After the uplift of the region, the surface-waters caused a secondary rearrangement of ores and of values within the ore-bodies to a surprising degree; and extensive migration of the metals from upper to lower horizons took place in the stratified rocks, invading even the upper portion of the hard and glassy, lower quartzite, where rich, secondary ores are found in vugs and water-courses below much larger masses of ore of lower grade in the limestones directly above.

These fissures and dikes exist only in the easterly portion of the Leadville district, within the so-called gold-belt, where the deposits carry gold in addition to the silver, lead, and other metals—no gold being found in the westerly portion of the district.

It seems reasonable to assert that the proximity of the gold-belt to the original fissures and dikes explains the existence of gold in the veins of that particular area. Gold would naturally be precipitated first; and thus it did not find its way, except in a solitary instance, to the westerly portion of the district.

Fig. 1, an ideal east and west section of Breece hill, fully illustrates the main features of these later developments.

In this connection, it occurs to me that other districts, such as the lead- and zinc-deposits of Missouri, have been interpreted wrongly in their genesis, since the discoveries in Leadville demonstrate that the original source of the ores may be situated

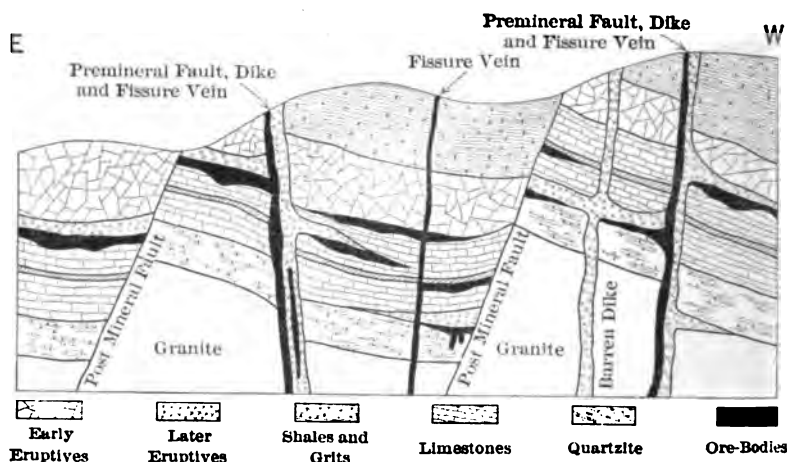


FIG. 1.—IDEAL SECTION OF BREECE HILL, LEADVILLE, COLO.

to the distance of a mile or more away from the ore-bodies found and developed in the mines.

I am sure that the most recent discoveries in Leadville throw much new light upon the difficult problem of the genesis of ore-bodies everywhere, and I hope that the U. S. Geological Survey will soon publish the result of its latest investigations in this district.

**Cyanide-Plant and Practice at the Minas del Tajo,
Rosario, Sinaloa, Mexico.**

BY GEORGE A. TWEEDY AND ROGER L. BEALS, ROSARIO, SINALOA, MEX.

(Pittsburg Meeting, March, 1910.)

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I. INTRODUCTION.

THE results of the cyanide-operations, given in detail in the following paper, show the progress that is being made at the Minas del Tajo. The old pan-amalgamation process, in operation up to and including 1905, while paying a profit on high-grade ores, was no longer able to treat profitably the ores in sight at that time; hence an alteration in the process was imperative. The success of this alteration is eloquently expressed by the following data :

	Pan-Amalgamation. 1905.	Cyanidation. 1907.	1908.
Tons treated,	51,387	58,983	69,200
Value per ton (U. S. currency), .	\$10.78	\$8.39	\$8.28
Extraction, per cent.,	65.00	88.56	87.45
Extraction, per ton,	\$7.00	\$7.43	\$7.24
Total cost, per ton treated, . .	6.50	4.36	4.01
Profit, per ton treated,	0.50	3.07	3.23

The item "total cost" in the foregoing tabulation includes everything—working-costs, development, management, general expenses, bullion-expenses, and taxes.

II. DEFINITIONS AND EXPLANATIONS.

The following definitions and explanations are given for the sake of clearness:

Slime.—That product, clayey in nature, consisting largely of decomposed feldspars and having the characteristics of a colloid.

Fine Sand.—Sand finer than 150-mesh, having a gritty feel and which will settle in water, leaving it clear in less than 1 minute.

Medium Sand.—Sand in size between 40- and 150-mesh.

Coarse Sand.—Sand in size coarser than 40-mesh.

Residue.—When used in speaking of assays, this term refers to samples dried without washing; in other words, containing a certain amount of cyanide solution and dissolved values.

Undissolved.—Assay of pulp after thorough washing (that is, after removal of all cyanide-solution and dissolved values).

Ton.—The short ton, 2,000 lb., is used in all instances.

Cyanide.—All strengths and figures are in terms of potassium cyanide.

Sodium Cyanide, equivalent to 130 per cent. KCN, is used in the plant.

Screen-Tests are made with the following sieves:

Mesh.....	40	60	80	100	150
Openings, mm.....	0.0407	0.0216	0.0169	0.0127	0.0083

Assay-Values and Costs are given in United States currency.

III. ORE.

Two classes of ore are mined and treated—namely, oxidized and unoxidized ore. Roughly speaking, all ore coming from below the 150-ft. level falls into the latter class. Of these two classes there are several types, differentiated by the ratio of their silver- and gold-content, proportion of heavy sulphides, and amenability to treatment by cyanidation. Each type in the unoxidized ore has its counterpart in the oxidized ore.

1. *Unoxidized Ore*.—Type 1, characterized by large propor-

tion of galena, not rich in silver, and presenting no difficulty in treatment.

Type 2, carrying a lesser proportion of galena, accompanied, however, with zinc-blende and chalcopyrite. Whenever this chalcopyrite is found the ratio of gold to silver increases. This type of ore is amenable to treatment, but causes a larger cyanide-consumption.

Type 3, clean ore, carrying very little base sulphides, with a greater ratio of silver to gold, and easily cyanided. The gangue of this type contains a considerable amount of rhodochrosite and feldspar.

2. *Oxidized Ore.*—The counterparts of these types in the oxidized ore are traced by their silver-gold content ratio, and by the presence of analogous minerals derived from the oxidation of the base sulphides, etc. For instance, Type 1 shows considerable lead carbonate; Type 2, a lesser amount of lead carbonate, accompanied by zinc carbonate and copper carbonates and oxides, while Type 3 contains manganese oxides, particularly psilomelane or wad.

All these types are amenable to cyanide-treatment, Type 2 causing the greatest cyanide-consumption, while Type 3 produces the most slime, due to the greater proportion of clay formed by the decomposition of the feldspars.

A typical analysis of Type 3, oxidized ore, is:

	Per Cent.
Copper,	0.2
Iron,	4.2
Zinc,	1.4
Manganese,	1.6
Lead,	trace
Lime (CaO),	1.2
Sulphur,	1.5
Insoluble (Al ₂ O ₃ -SiO ₂),	82.8
Undetermined,	7.1
Oz. Per Ton.	
Gold,	0.20
Silver,	8.60

The sulphur is partly combined as sulphide and partly as the sulphates, FeSO₄ and Fe₂(SO₄)₃, the acid sulphate accounting for the greater acidity of this class of ore. The undetermined comprises CO₂, oxygen of the sulphates, and oxygen combined with manganese, etc.

IV. PRELIMINARY EXPERIMENTS.

Before the erection of the mill and cyanide-plant experiments were conducted to determine the best method of treatment. A comparison of the results obtained experimentally with the results in the completed mill is interesting.

The ore experimented upon was the unoxidized class. Samples were taken from various parts of the mine and treated separately, then a general sample of the unoxidized ore was tested. The first work was with 100-lb. samples, these being crushed and ground in a sample-grinder and classified into sand and slime. The sand was leached in small tubs, 18 in. in diameter by 18 in. deep, while the slime was treated by agitation in the same sized tubs fitted with cross-arm stirrers.

Extremely erratic results were obtained with the sand-leaching. The lower half of the sand in the tubs behaved as does the lowest 6-in. layer in a large tank, being slow to drain and retaining a great deal more moisture than the top sand; the upper half behaved as does the top 6-in. layer of sand in large tanks. The varying amount of solution retained by the sand destroyed the value of the work, and it is for this reason that leaching-tests in small tubs were unreliable. On the other hand, the tubs fitted with stirrers for treating the slime more nearly approximated the working-conditions, the results being uniform and reliable.

The dissolution of the gold and silver and the greatest permissible size of grain were determined by bottle-tests, using bottles holding from four to seven times the volume of air to that of the pulp; these tests showed that on ore finer than 40-mesh more than 90 per cent. of the values could be dissolved in four days.

Tests for the determination of the acidity of the ore were made in bottles, agitating the samples with solution of sodium hydrate; the average of the tests gave an acidity equal to 7 lb. of lime per ton of ore, this high consumption being due chiefly to the ore from old stope-filling containing organic matter.

The lime obtainable contained only 40 per cent. effective CaO ; thus the actual lime-consumption was from 14 to 17 lb. per ton of ore.

Bottle-tests for cyanide-consumption indicated a chemical consumption of from 1.5 to 2.1 lb. per ton, provided the pro-

protective alkalinity did not drop below 0.02 per cent. of CaO. This was corroborated by tests of sand in 5-ton lots. It was found that, even after 10 days' leaching, the cyanide-consumption would rapidly rise if the protective alkalinity dropped below 0.02 per cent. of CaO. Lime crushed not finer than 20-mesh gave the best results; this, mixed with the ore, slowly went into solution as needed, the leachings coming off alkaline to the end of the treatment.

Milk of lime was unsatisfactory, as it gave up its alkalinity too quickly.

V. MILL-RUN TESTS.

The feasibility of collection of sand, leachability, and extraction on a working-scale were determined by small mill-runs, the ore being crushed in 5- and 10-ton lots in a five-stamp battery; the pulp was run to a pit, where the sand was collected, the slime overflowing through a gate and settling in a tank below the pit, the overflow being regulated by raising the gate.

In the mill-runs a punched screen having openings equal to 0.6 mm. was used, and screen-tests showed approximately 35 per cent. slime, while from 3 to 8 per cent. of the sand was coarse.

The value and amount of the various sized products are given in Table III., which shows that the chief values lie in the medium to fine sand, while the product coarser than 40-mesh is lower in value than the original sample.

On this latter product an extraction of about 60 per cent. was obtained. Allowing 10 per cent. of this size in the sand separated from ore carrying 8 oz. of silver per ton, there would be, on a 1-ton basis, 200 lb. of pulp carrying from 4 to 6 oz. per ton, of which 60 per cent. could be extracted, leaving 200 lb. of pulp, assaying 2 oz. of silver per ton, and representing 0.2 oz. of silver per original ton of ore. By regrinding this product a further extraction representing 0.1 oz. of silver per ton of ore could be recovered. This extra recovery from fine grinding would not pay for the cost of the work.

The sand collected was found to be easily leachable, though containing 7 per cent. of slime. Charges of 5 tons were treated from 8 to 10 days. The strength of solution found best in the bottle-tests—namely, 0.3 per cent. of KCN—was used for the first two days' treatment. The tank was then aerated for a

TABLE I.—*Results of Leaching-Tests on Sand.*

Weight of sand, 3.37 tons.

Per cent. of moisture, 18.

Weight of lime added, 32 lb.

Charging-value of sand, 0.42 oz. gold, 10.0 oz. silver per ton.

Screen-Test.		Gold-Assay.		Silver-Assay.	
Size.	Quantity.	Heads.	Tails.	Heads.	Tails.
	Per Cent.	Ounces Per Ton.	Ounces Per Ton.	Ounces Per Ton.	Ounces Per Ton.
On 40.....	3.9	0.25	0.040	6.2	2.4
On 60.....	20.0	0.28	0.022	5.3	1.2
On 80.....	21.7	0.30	0.015	7.2	0.9
On 100.....	5.8	0.29	0.010	7.4	1.0
On 150.....	28.1	0.50	0.014	10.0	1.1
Through 150....	20.5	0.71	0.012	19.0	1.4

Solution.	Strong Solution.		Leachings.		Consumption KCN Per Ton Solution.	Undissolved.		Residue.	
	KCN.	CaO.	KCN.	CaO.		Au.	Ag.	Au.	Ag.
Tons.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Pounds.	Oz. Per Ton.	Oz. Per Ton.	Oz. Per Ton.	Oz. Per Ton.
2.31	0.34	0.12	0.24	0.10	4.62	0.065	3.32	0.28	8.0
2.13	0.22	0.10	0.22	0.15	.....	0.03	2.07	0.12	6.0
2.07	0.27	0.09	0.23	0.06	.....	0.01	1.74	0.04	3.5
1.78	0.30	0.07	0.23	0.06	0.71				
1.61	0.28	0.09	0.26	0.08	0.64	0.01	1.45	0.03	3.0
1.28	0.27	0.09	0.24	0.09	0.76	0.012	1.29	0.02	2.2
1.28	0.26	0.09	0.24	0.10	0.76	0.01	1.22	0.016	1.6
1.03	0.54	0.12	0.26	0.08	5.76	0.011	1.16	0.014	1.3
0.55	0.36	0.12	0.30	0.08	0.66				
0.26	water	wash	0.38	0.07	+2.17				
2.00	water	wash	0.10	0.06	+4.35	0.012	1.15	0.015	1.17

Percentage of extraction by residue, gold, 97.0 ; silver, 89.6 per cent.

Cyanide-consumption, 2.2 lb. per ton sand.

Time of treatment, 11 days. Solution added twice daily.

day, and solutions again added. Between the additions of solution the tank was thoroughly drained. The leachings were passed through a zinc-box and returned to the storage-tank, the precipitated solution thus being used repeatedly.

The effectiveness of the solution after use was determined by using 2 tons of solution for the treatment of five lots of ore of 5 tons each. The solution was in use for six weeks, being precipitated after each passage through the sand, and evaporation-losses made up by addition of water. At the end of this period it was as effective for all purposes as at the beginning. The precipitation was good, the solution leaving the boxes

carrying 0.05 oz. of silver per ton, and a trace of gold. The consumption of zinc was 0.8 lb. per ton of ore treated.

The net result of these leaching-tests showed :

1. That the extraction of gold and silver was good.
2. That the dissolution of the gold was very rapid, the silver going into solution more slowly.
3. That the best results were obtained by allowing the charges to drain thoroughly before each addition of solution.
4. That the leaching-rate was 4 to 6 in. per hour, and that no serious fouling of working solution took place.

Full data of one of the leaching-tests are given in Table I.

The collected slime from the test-runs was treated, in small tanks fitted with mechanical stirrers, by agitation and decantation in solution averaging 0.20 per cent. of KCN. The extraction was: gold, 94, and silver, 88 per cent.

The consistency of the pulp giving the best results was 4 of solution and 1 of dry slime. The slime settled to 52 per cent. of moisture in 12 hours.

The dissolution of the silver, commercially profitable to dissolve, took place in the time necessary to mix and decant the solution, giving five decantations, hence the washing-out of the values dissolved was the most important part of the test.

Table II. gives the results of the treatment of one charge of slime.

TABLE II.—*Results of Tests on Slime.*

Weight of wet slime charged, 20 kg.

Assay, gold, 0.20 oz. per ton; silver, 9.60 oz. per ton.

Moisture in charge, 45 per cent.

Weight of dry slime, 11 kg.

There was added at the beginning of the first treatment 120 g. of KCN and 105 g. of lime.

Water Added.	Time of Treatment.	Solution Decanted.			Undissolved.		Residue.	
		Quantity.	Composition.		Gold.	Silver.	Gold.	Silver.
			KCN.	CaO.				
Kg.	From to	Kg.	Per Cent.	Per Cent.	Oz. Per Ton.	Oz. Per Ton.	Oz. Per Ton.	Oz. Per Ton.
35.0	8 a.m. 5 p.m.	27.0	0.23	0.05	.....	.....	.....	.....
.....	 2 p.m.	.....	.....	.....	0.02	3.80	.....	.....
.....	 5 p.m.	.....	.....	.....	0.01	1.29	.....	.....
30.0	2 p.m. 6 p.m.	29.0	0.09	0.02	0.007	0.79	0.015	1.49
30.0	9 a.m. 2 p.m.	29.0	0.05	0.01	.....	.....	0.007	0.88

Percentage of extraction by residue, gold, 95; silver, 90 per cent.

Cyanide-consumption: Chemical, 1.6; mechanical, 1.7 lb. KCN; total, 3.3 lb. KCN per ton.

Table III. gives the results of one of the battery-runs, showing the amount and assay of the various-sized products of the battery-pulp before treatment, and of the classified sand before and after treatment.

TABLE III.—*Results of the Battery-Tests.*

	Battery-Sample.				Sand-Sample.			
Screen Size.	Value.		On Screen.	Heads.		Tails.		
	On Screen.	Gold. Silver.		Gold.	Silver.	Gold.	Silver.	
	Per Cent.	Oz. per Ton.	Oz. per Ton.	Per Cent.	Oz. per Ton.	Oz. per Ton.	Oz. per Ton.	
On 40.....	2.51	0.24	6.1	3.9	0.30	6.2	2.5	
On 60.....	11.08	0.19	4.2	20.0	0.29	5.4	1.6	
On 80.....	1.52	0.25	5.8	21.7	0.30	7.2	1.2	
On 100.....	3.70	0.27	5.8	5.8	0.29	7.4	0.83	
On 150.....	17.30	0.42	8.6	28.1	0.50	11.4	1.2	
Through 150.....	50.1	0.61	14.1	20.5	0.86	20.2	1.5	
Through 150, sand..	16.5	1.10	19.2	14.8	1.05	24.0		
Through 150, slime.	33.6	0.37	11.7	5.7	0.19	10.0		

VI. CONCENTRATION EXPERIMENTS.

To determine the advisability of concentration of the ore, a sample of the sand in each charge was concentrated before and after treatment with cyanide. The amount and value of the concentrate obtained were not sufficient to justify concentration; moreover, the concentrate obtained from the treated sand showed that a good extraction was obtained from it in the tanks. A slightly increased extraction could be made by separating and regrinding, but this increased extraction was not sufficient to justify the erection of an extra plant.

The average results of a number of tests were :

	Assay-Value.	
	Gold.	Silver.
	Oz. Per Ton.	Oz. Per Ton.
Concentrate from sand before treatment, .	3.25	26.7
Amount of concentrate recovered, . . . 1.2 per cent.		
Ounces in concentrate per ton of sand, .	0.039	0.3
Concentrate after treatment of sand, . .	0.62	4.6
Ounces in concentrate per ton treated sand,	0.006	0.05
Extraction on concentrate by cyanidation of sand,	79.9	82.8

VII. OUTLINE OF OPERATIONS.

The ore from the mine is crushed by a No. 5 Gates breaker, style K, to pass a 2-in. ring. The breaker is fed from two 200-

ton bins, and the ore, after crushing, is elevated by inclined belt to the fine-ore bins.

The mill and cyanide-plant are situated on the Rosario river, half a mile from the mine, the ore being hauled to the mill by a light locomotive in gable-bottom cars, holding 15 tons. A

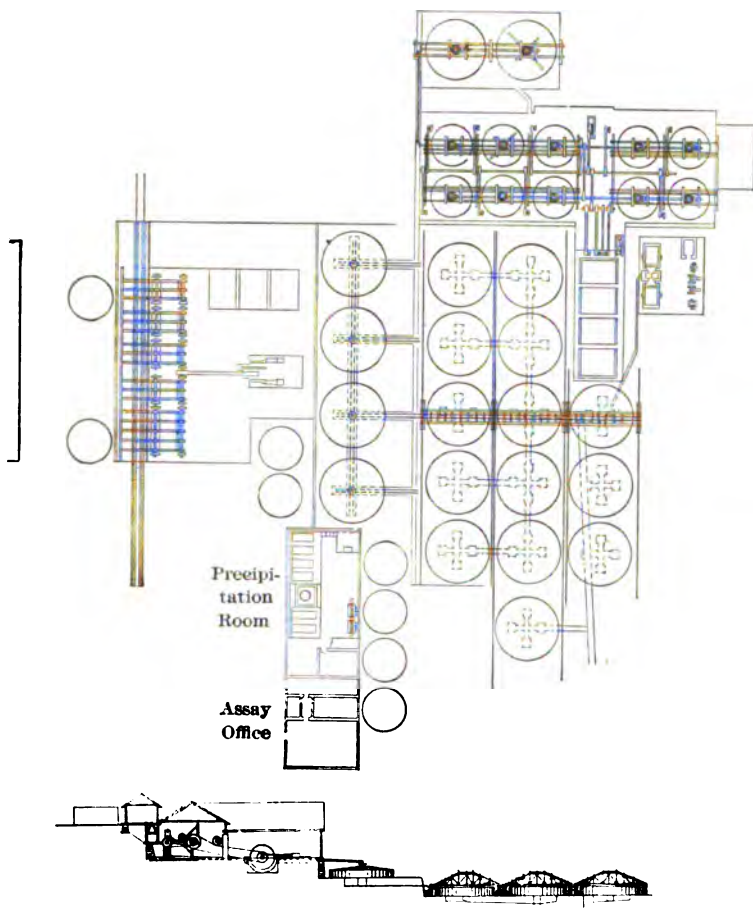


FIG. 1.—PLAN AND SECTIONAL ELEVATION OF MILL AND CYANIDE-PLANT.

plan and elevation of the mill and cyanide-plant are given in Fig. 1, and various photographic views of the plant in Figs. 2 to 5 and Figs. 7 and 15. The bins at the mill have a capacity of 600 tons.

The ore is fed from the mill-bins by automatic feeders to 12 batteries of 5 stamps each, crushing in cyanide solution.

Lime is added to the ore in the bin as needed. The alkalinity of the battery-solution is maintained at 0.05 per cent. of CaO .

From the batteries the pulp flows directly to four sand-collecting tanks, each holding 145 tons of dry sand. The pulp is distributed by radial-arm distributors, fitted with ball-bearings, each tank being equipped with a distributor. The sand settles, and the slime overflows through four curtained gates to a launder leading to the slime-plant.

The two slime-collecting tanks are 35 ft. in diameter by 9.5 ft. deep, set in series, so that the pulp enters one and overflows to the second. The overflow from the second tank runs to a concrete sump, and is then pumped back to the battery-supply tank above the mill.

The sand, after collection and thorough draining, is transferred by cars to the leaching-tanks, 14 in number. After treatment the sand is sluiced to the river.

The thickened slime is withdrawn at regular intervals from the slime-collecting tanks. The treatment of this slime, by agitation and settlement, takes place in nine tanks, each 24 ft. in diameter by 9.5 ft. deep. From the treatment-tanks the slime is transferred to a tank of the same size, supplying the filters. After filtration the slime is washed to the river.

The solutions from the sand- and slime-plant are collected in sumps built of brick and faced with cement. Centrifugal pumps, driven by the engine running the slime-plant, handle the solutions. The water for the mill and mine is supplied by steam-pumps situated in a well connected by a tunnel with the river.

VIII. MILLING.

The mill consists of 12 batteries of 5 stamps set on concrete-mortar blocks. The battery-frame is of the front-knee pattern, the sills anchored in concrete by 1.5-in. bolts. In laying the concrete great care was taken in tamping and in adding but small amounts of material at a time. The blocks have not shown the slightest tendency to crack.

Each mortar weighs 5 tons. Though designed for double discharge, they now have the backs blocked up with a heavy cast-iron plate and are fitted with liners. The mortars were planed on their bases, and the tops of the concrete blocks were finished carefully with neat cement. Between mortar and block



FIG. 2.—VIEW OF PLANT; SLIME-TREATMENT TANKS IN THE FOREGROUND.



FIG. 3.—VIEW OF PLANT; SLIME-TREATMENT TANKS IN THE FOREGROUND.



FIG. 4.—COLLECTION-TANKS WITH RADIAL-ARM DISTRIBUTORS.
[11]



FIG. 5.—LEACHING-TANKS, TRAVELING-BRIDGE FOR CHARGING SANDS.



FIG. 7.—SLIME-TREATMENT TANKS WITH OVERHEAD TRAVELING-BRIDGES.



FIG. 15.—PRECIPITATION-ROOM, SHOWING THE ZINC BOXES.

a $\frac{1}{8}$ -in. sheet of rubber is placed; eight bolts, 1.5-in. in diameter, are used to hold the mortar rigidly in place on the block.

The gross weight of the falling-stamp with new shoe is: stem, 450; boss, 350; tappet, 120; shoe, 180; total, 1,100 lb. The average running weight is 1,010 lb. The weight of the die used, when new, is 140 pounds.

The stamps drop 6.5 in. 104 times per minute. Wooden guides are used, which last from eight to ten months; the wood is native and is extremely hard and of fine grain.

A cross-compound, slide-valve engine drives a line-shaft running the batteries, eight having separate drive, while four are driven in pairs, ten stamps to a shaft; however, the separate drive for each battery is preferable. Idler pulleys are used as belt-tighteners. For the 60 stamps 125 h.p. is required.

The cam-shafts driving five stamps are 6 in. in diameter, while those driving ten stamps are 6.5 in. The cams are of the Blanton self-locking type.

When crushing with double discharge it was found that an excessive amount of solution was necessary in order to maintain a proper wash in the mortars, from 10 to 12 tons being required per ton of ore. With single discharge, the same amount was crushed with 6 tons of solution. It was for this reason that the back discharge was blocked up with a cast-iron plate and the mortar narrowed by liners. Chuck-blocks are used to maintain the discharge at from 2.5 to 3 in., which is the height of greatest capacity.

The endeavor was to obtain as great a capacity per stamp as possible, with the condition of keeping the amount of coarse sand under 6 per cent. Various types of screens have been tried to achieve this result.

Using woven-wire screens, crushing in cyanide solution carrying from 0.04 to 0.08 per cent. of CaO, the lime built up on the screens and choked them, closing the holes as with a cement. Frequent brushing was necessary to keep the holes clear, and this broke the screens; 30-mesh iron-wire screens were tried and discarded. Heavy punched plate having holes 0.6 mm. in diameter gave a proper-sized product, and no trouble from lime-deposition; but the capacity was low, since the holes were spaced too far apart and the plate was too heavy. Diagonal-slot screens, the slots 0.6 mm. wide, gave capacity, but as they

rapidly wore to 1 mm. and larger at the lower end of the slot, the product was too coarse.

It was finally found that thin punched tinned screens gave the best results; these last 15 or 20 days as compared with 30 or 40 days when using the heavy plate. Their cost is such, however, that though lasting but half the time, the screen-cost per ton crushed is one-third of that resulting from the use of heavy plate.

The stamp-duty varies with the class of ore. The oxidized ore coming from the open-cut and upper levels of the mine is very soft and friable, consisting largely of decomposed andesite with the feldspars changed to clay. Unoxidized ore from the lower levels is hard; much of the quartz in it is like flint. Crushing this latter, the stamp-duty is about 3.5 tons. With a mixture of the two classes containing from 20 to 30 per cent. of oxidized ore, the stamp-duty is increased to 4 tons.

The quantity of slime in the pulp from the stamps increases from 35 per cent. in crushing unoxidized ore to 45 per cent. in crushing a mixture of oxidized and unoxidized, the screens, discharge, drop, and solution used being the same in each case.

The number of tons crushed and the quantity of slime per stamp were:

Screen Used.	Tons Per Stamp.	Slime. Per Cent.
0.6 mm., heavy plate.	3.25	35.5
0.6 mm., heavy plate.	3.60	40.4
1.0 mm., heavy plate.	4.00	41.4
0.6 mm., thin tinned plate.	4.04	44.5
0.6 mm., thin tinned plate.	4.78	45.2

The character of the product of the stamps when using different screens is given in Table IV.

TABLE IV.—*Results of Using Various Screens.*

Sample of Pulp.	On 40.	On 60.	On 80.	On 100.	On 150.	Through 150.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
A.	12.0	18.0	15.0	10.0	10.0	35.0 (5 of sand, 30 of slime).
B.	8.0	18.0	16.0	11.0	11.0	36.0 (7 of sand, 29 of slime).
C.	5.0	14.0	12.0	9.0	18.0	42.0 (10 of sand, 32 of slime).
D.	4.5	16.5	15.5	15.0	13.5	35.0 (9 of sand, 26 of slime).

A. Through a 0.6-mm. slot screen.

C. Through a 0.6-mm. punched plate.

B. Through a 1.0-mm. punched plate.

D. Through a 0.6-mm. tinned plate screen.

Different makes of shoes and dies have been tried, but no advantage was found in using a shoe of one class and a die of another. Good steel shoes and dies give no trouble from cupping; the shoe wears down from 180 to 40 lb. and the die from 140 to 35 lb. Cast-iron dies were tried and found unsatisfactory, costing more per ton crushed, and wearing unevenly; moreover, they did not keep the shoe in any better condition than the steel dies. The consumption of steel in shoes, per ton of ore crushed, was 0.52 pound.

The pulp from the batteries is delivered to a V-shaped launder running to the sand-collecting tanks. The launder is set on a grade of 2.75 per cent., which is sufficient to keep the launder clear, when using 6 tons of solution per ton of ore. A straight launder would carry the pulp with less grade, but where the pulp from the stamps enters, the flow in the launder is rhythmical, and a lesser grade was found insufficient to carry the ore.

As the mill-site is comparatively flat, launders were placed at the minimum possible grade; in fact, it was only by doing this that the necessity of elevating the pulp was avoided.

Table V. shows the average costs of milling 41,465 tons of ore, covering a period of seven months:

TABLE V.—*Summary of Costs of Milling.*

	Per Ton Milled.
Labor, native,	\$0.0583
Employees, white.	0.0080
Shoes,	0.0275
Dies,	0.0162
Belting, lacing,	0.0116
Stems, screens,	0.0070
Cocks, valves,	0.0021
Lubricant and miscellaneous,	0.0075
Power,	0.3500
Total,	<u>\$0.4882</u>

The labor-cost is total, including that in the shops and mill indirectly chargeable to crushing, as also maintenance and repairs. The power-item is 71 per cent. of the cost of milling. Wood is used as fuel and costs \$5.50 per cord of 180 cubic feet.

IX. CYANIDING.

1. *Sand-Plant.*

There are four redwood collecting-tanks, each 35 ft. in diameter by 4.5 ft. deep, fitted with pine filter-bottoms supporting cocoa-matting and 6-oz. duck filter-cloth. The filter-cloth is protected by 1.5-in. strips spaced 2 in. apart. The filter and strips take up 6 in. of the depth of the tank.

Each tank has a radial-arm distributor, and four side-outlets for the overflow of slime. The outlets are 4-in. pipes, and have a lattice and curtain in front to control the overflow. There are also four bottom-doors.

The pulp from the batteries is delivered to the hopper of the distributor and spread over the tank (Fig. 4). The sand settles, while the slime overflows the curtains and is delivered to a launder running to the slime-plant. As the sand collects the curtains are raised, the endeavor being to overflow as much of the slime as possible. During the collection and until the charge is transferred to the treatment-tanks, the sand is drained by two pipes leading from the bottom of the tank. A charge amounting to 145 tons drains to 15 per cent. of moisture after 30 hours.

Charges are allowed to stand as long as possible before transferral, usually 60 hr. The sand is then shoveled through the bottom discharge-doors to cars, and charged into the treatment-tanks. Low, wide, gable-bottom 2-ton cars are used. The turntables beneath the tanks have ball-bearings which permit very easy handling of the cars.

The cars containing the sand are trammed over the treatment-tanks on movable bridges (Fig. 5). Two cars are handled at a time; the sand is charged evenly over the surface of the tank and leveled off. The traveling-bridges are a cheap and efficient means of filling the tanks, and no vibration is transmitted to the tank to cause settling and channeling of the sand. The work of charging, done by contract, costs \$0.05 per ton.

The leaching-tanks, 14 in number, are the same size as the collecting-tanks. The canvas filter is held in place by 0.5 by 1 in. strips spaced 5 in. apart and radiating from the discharge-

doors, which protects the cloth while the sand is being discharged.

In charging the tanks the sand increases 20 per cent. in volume. Strong solution is run on immediately after charging, and the sand allowed to soak for 6 hr. The charge subsides during this time and occupies about 24 cu. ft. to the ton. Before charging, the sand will occupy from 20 to 22 cu. ft. per ton.

The sand leaches rapidly and drains to 25 per cent. of moisture in 6 hr. After the first addition of solution and draining, the leaching-cocks are left open for all succeeding leaches till the tank is ready to be discharged.

The solution from the slime-plant, consisting of the decantations from the last treatments of the slime, is pumped to two supply-tanks situated above the sand-plant. This solution, which carries from 1 to 1.5 oz. of silver and from 0.03 to 0.06 oz. of gold, is brought up to a strength of 0.25 per cent. of KCN by addition of cyanide. This solution is used for the first or strong washes on the sand, being run on the tanks every 8 hr. with continuous draining. The tanks drain to from 22 to 25 per cent. of moisture between the additions of solution.

When the silver dissolves rapidly the addition of strong solution is stopped after three days, and solution from the slime-plant is used without addition of cyanide. It takes from three to seven days to bring the undissolved value of the sand to less than 2 oz. of silver per ton. The charge is then allowed to aerate from two to three days.

The solutions from this first period of treatment are collected in a sump and pumped to the high-grade solution-tank above the precipitation-boxes.

After precipitation, the solution is used for the barren leaches, being put on the sand after it has been thoroughly aerated. This precipitated solution, titrating from 0.15 to 0.25 per cent. of KCN, is used for from three to six days until the residue and undissolved values of the sand are approximately equal. When the leaches drop in value to 0.4 oz. of silver and 0.01 oz. of gold per ton, the tank is allowed to aerate a second time for two or three days. The leachings during this second period are collected in a separate sump. The sump-solution, assaying from

1 to 2 oz. of silver per ton, is pumped to the second tank above the precipitation-boxes.

After the second aëration, water-washes, in lots of 10 tons each, are continued usually for two days, and the drainings drop to 0.1 oz. of silver per ton, a trace of gold, and a cyanide-content of from 0.02 to 0.03 per cent. of KCN.

After the final water-washes, the tank is drained and sluiced to the river through the four bottom-doors. It takes from 8 to 10 hr. to discharge the sand, since the tanks are shallow. One man using a 2-in. hose, under a 40-ft. head, washes out the sand, the launders carrying the discharged sand having a 3-per cent. grade.

The total time of treatment is approximately 18 days, which allows for from four to six days' aëration in the tanks. Without this aëration a much larger quantity of solution is necessary to accomplish the work.

The leaching-tanks are fitted so that the precipitated solution or barren washes may be applied from beneath. This is seldom done, however, except in the case of a charge which is slow to dissolve.

The work in the plant has shown that, provided the metal in the ore is soluble, it can be dissolved and removed from sand as rapidly as from slime, and more cheaply. The essential point is that the charge of sand shall be uniform and leachable. The cost of treating sand is much less than that for slime, and for this reason the endeavor has been to treat as sand as much of the product as possible.

The ore treated during the first year of the present plant was almost entirely unoxidized ore, and weak solutions were used. The second year a large amount of oxidized ore, often containing much organic matter from the surface-soil mixed with it, was treated. This ore contained in addition a large amount of manganese dioxide in the form of wad, and gave difficulty in both the sand- and slime-plants. To date, no certain remedy has been found to overcome the difficulty due to the manganese. The trouble is one that will have to be solved by chemistry. Fine-grinding tests have shown no increase in extraction. The use of bromocyanogen has, in some experiments, given a slightly better extraction than with cyanide alone.

Tables VI. to XI. give the details of operations at the sand-plant.

TABLE VI.—*Results of Operations at the Sand-Plant, 1907.*

The ore treated was unoxidized mine-ore. The strength of the strong solution was 0.20 per cent. of KCN.

1907, Month.	Quantity of Sand. Tons.	Assay of Heads.		Values in Sand.		Assay of Tailings.		Quantity Recovered.	
		Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
		Oz. per Ton.	Oz. per Ton.	Fine Oz.	Fine Oz.	Oz. per Ton.	Oz. per Ton.	Fine Oz.	Fine Oz.
Mar.....	3,190	0.168	4.68	536.50	14,984.0	0.01	0.77	504.60	12,469.0
April.....	2,900	0.147	5.09	429.20	14,762.0	0.01	0.75	400.20	12,572.5
May.....	3,190	0.139	4.78	443.70	15,257.5	0.01	0.73	411.80	12,908.5
June.....	3,190	0.167	4.63	583.30	15,094.5	0.01	0.78	501.40	12,586.0
July.....	3,335	0.149	3.45	497.35	11,613.0	0.01	0.74	474.00	9,083.5
Aug.....	3,080	0.188	4.97	579.60	15,390.0	0.01	1.24	548.80	11,508.0
Total.....	18,885	0.159	4.60	3,019.65	86,891.0	0.01	0.84	2,830.80	71,077.5
		\$5.59		\$105,361.67		\$0.63		\$94,051.39	

Average recovery for the six months : gold, 93.7 ; silver, 81.8 per cent. With silver at \$0.50 per oz. the combined extraction is 88.8 per cent.

TABLE VII.—*Results of Operations at the Sand-Plant, 1908.*

There was an increased amount of oxidized ore in July, while the ore milled during most of the period was nearly half oxidized. The strength of the strong solution was 0.20 per cent. of KCN.

1908, Month.	Quantity of Sand. Tons.	Assay of Heads.		Values in Sand.		Assay of Tailings.		Quantity Recovered.	
		Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
		Oz. per Ton.	Oz. per Ton.	Fine Oz.	Fine Oz.	Oz. per Ton.	Oz. per Ton.	Ounces.	Ounces.
Feb.....	3,045	0.181	4.62	553.90	13,775.0	0.01	0.94	523.45	10,904.0
Mar.....	3,335	0.157	4.82	524.90	16,080.5	0.01	0.97	491.55	12,832.5
April.....	3,480	0.137	4.96	482.85	17,284.0	0.01	0.49	438.05	15,585.3
May.....	2,900	0.156	5.33	453.85	16,457.0	0.01	1.10	424.85	13,267.0
June.....	3,045	0.171	5.73	521.00	17,458.0	0.02	1.10	460.10	14,108.5
July.....	3,045	0.180	5.59	626.40	19,474.0	0.02	1.50	556.80	14,254.0
Total.....	18,850	0.167	5.33	3,162.90	100,528.5	0.013	1.03	2,904.90	80,951.3
		\$6.12		\$115,641.39		\$0.78		\$100,519.93	

Average recovery for the six months : gold, 91.8 ; silver, 80.5 per cent. With silver at \$0.50 per oz. the combined extraction is 87.4 per cent.

TABLE VIII.—*Results of Operations at the Sand-Plan, 1909.*

1909, Month.	Quantity of Sand.	Assay of Heads.		Assay of Tailings.		Recovery.	
		Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
	Tons.	Oz. per Ton.	Oz. per Ton.	Oz. per Ton.	Oz. per Ton.	Per Cent.	Per Cent.
March.....	3,190	0.269	5.69	0.02	1.15	92.5	79.8
April.....	3,045	0.241	6.25	0.02	1.40	91.7	77.6
May.....	3,190	0.260	6.55	0.02	1.30	92.3	80.15
June.....	3,335	0.231	6.52	0.02	1.30	91.3	80.0
	12,760	0.250	6.25	0.02	1.29	92.0	79.3
		\$8.28		\$1.05		87.3	

A diagrammatic chart showing the dissolution and extraction of gold and silver from a charge of sand is given in Fig. 6.

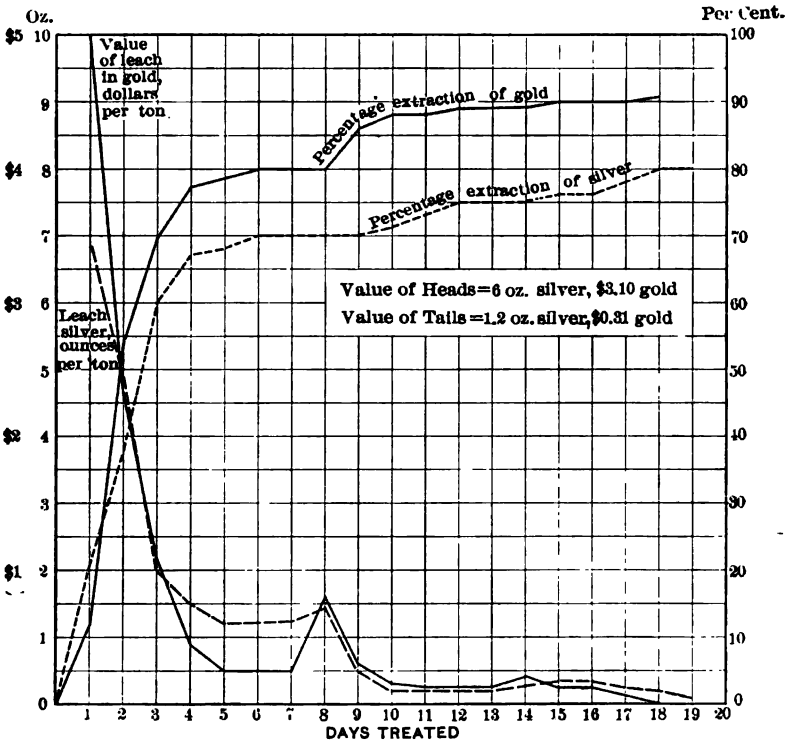


FIG. 6.—CHART SHOWING DISSOLUTION AND EXTRACTION OF GOLD AND SILVER FROM A CHARGE OF SAND.

TABLE IX.—*Screening-Tests at the Sand-Plant.*

Size.	Unoxidized Ore.					Oxidized Ore.				
	Quantity.	Heads.		Tails.		Quantity.	Heads.		Tails.	
		Gold.	Silver.	Gold.	Silver.		Gold.	Silver.	Gold.	Silver.
		Per Cent.	Oz. per Ton.	Oz. per Ton.	Oz. per Ton.		Per Cent.	Oz. per Ton.	Oz. per Ton.	Oz. per Ton.
Unscreened.....	.....	.....	0.34	4.5	0.015	.....	.....	0.22	6.4	0.02
Screen 40.....	9.0	0.12	2.2	0.025	1.4	11.0	0.20	4.4	4.0	0.02
Screen 60.....	20.0	0.16	2.6	0.020	0.9	24.5	0.14	4.0	0.02	1.8
Screen 80.....	22.0	0.40	2.8	0.012	0.8	20.5	0.14	4.3	0.015	1.8
Screen 100.....	11.0	0.36	3.2	0.010	0.8	13.2	0.20	5.4	0.015	2.2
Screen 150.....	16.0	0.42	4.1	0.013	0.8	15.0	0.20	5.4	0.02	2.1
Through 150.....	21.0	0.48	9.0	0.015	1.3	15.2	0.26	13.2	0.03	3.0

TABLE X.—*Sizing-Tests of Sand, Using Different Battery-Screens.*

Battery-Screen.	Quantity by Weight.					Through 150.
	On 40.	On 60.	On 80.	On 100.	On 150.	
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	
0.6-mm. slot.....	10.0	20.0	17.0	13.0	15.0	25.0 (21.0 sand, 4.0 slime).
1.0-mm. needle.....	11.7	19.5	19.2	13.2	19.7	18.7 (16.0 sand, 2.7 slime).
0.6-mm. needle.....	9.0	21.0	17.0	11.0	16.0	26.0 (21.0 sand, 5.0 slime).
0.6-mm. tin.....	5.0	19.3	12.6	12.3	19.0	30.3 (24.0 sand, 6.0 slime).
0.6-mm. tin.....	8.5	24.5	22.0	7.0	16.0	22.0 (14.0 sand, 8.0 slime).
0.6-mm. tin.....	5.0	18.5	17.6	16.6	32.3	10.0 (8.5 sand, 1.5 slime).

TABLE XI.—*Results of a Typical Treatment of Sand.*

Charge, 145 tons of sand. Collected, 9N6.

Residue: gold, 0.26 oz.; silver, 7.1 oz. per ton. Drained from 9 N 6 to 4 N 10.

Undissolved: gold, 0.18; silver, 5.7 oz. per ton.

Dissolved: gold, 30.7; silver, 19.7 per cent. Transferred to treatment-tank, 12 D 10.

Solution added three times daily. The quantity given is the sum of the additions.

Day.	Solution.		Leachings.				Undissolved.		Residue.	
	Strength.		KCN.		CaO.		Gold.		Silver.	
	Quantity.		KCN.		CaO.		Gold.		Silver.	
	Tons.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Oz. per Ton.	Oz. per Ton.	Oz. per Ton.	Oz. per Ton.	Oz. per Ton.
1	44	0.23	0.01	0.12	0.08	0.256	5.35	0.12	4.0	0.19
2	43	0.20	0.03	0.15	0.08	0.180	4.50	0.06	3.3	0.13
3	46	0.25	0.05	0.15	0.07	0.120	2.77	0.04	2.2	0.09
4	47	0.20	0.08	0.17	0.07	0.07	1.60	0.04	1.8	0.08
5	40	0.15	0.03	0.20	0.08	0.03	1.00	0.03	1.7	0.06
6	Charge aerated.									
7	Charge aerated.									
8	Charge aerated.									
9	41	0.13	0.09	0.13	0.08	0.05	1.70	0.02	1.5	0.04
10	44	0.14	0.09	0.12	0.07	0.028	0.80	0.02	1.4	0.03
11	44	0.18	0.09	0.12	0.07	0.020	0.50	0.01	1.4	0.03
12	44	0.19	0.09	0.11	0.08	0.014	0.44	0.015	1.2	0.03
13	Charge aerated.									
14	Charge aerated.									
15	35	water	wash	0.11	0.08	0.019	0.48	0.02	1.0	0.02
16	12	water	wash	0.07	0.07	0.01	0.50	0.015	0.9	0.02
17	35	water	wash	0.04	0.06	0.005	0.20	0.015	1.0	0.01
18	23	water	wash	0.02	0.07	0.002	0.06	0.015	1.0	0.02
Recovery.....									Per Ct.	Per Ct.
									92.3	85.9

The slime was separated from the product finer than 150-mesh by washing and settling, that portion being taken as sand that would settle and leave the solution clear in 30 seconds.

A summary of the cost per ton of sand treated for a period of seven months, based on a total quantity of 23,925 tons, is given in Table XII.

TABLE XII.—*Cost Per Ton of Sand Treated.*

Labor (native),	\$0.1066
Employees (white),	0.0324
Cyanide,	0.2367
Lime,	0.1040
Filter-cloths,	0.0074
Shovels,	0.0028
Pipe and sundries,	0.0025
Miscellaneous,	0.0130
Power,	0.0934
Total,	\$0.5988

2. *Slime-Plant.*

The slime-plant consists of two collecting-tanks, 35 ft. in diameter by 9 ft. 6 in. deep, and ten treatment-tanks, 24 ft. in diameter by 9 ft. 6 in. deep, with filter-presses, necessary pumps, etc. All the tanks are of redwood with 3-in. staves.

The treatment-tanks are arranged in two lines of five tanks each (Fig. 7). Each tank is equipped with a mechanical agitator consisting of two cross-arms, driven by crown-wheel and spur-gear from a line-shaft over the top of the tanks. The friction-clutch (Fig. 8) used in driving each gear has proved efficacious in saving gears, is simple, and does not get out of order. There has been but one gear replaced in two years. The arms revolve six times per minute.

There is a 4-in. centrifugal pump connected to each tank. These pumps are driven by friction-clutch pulleys from a line-shaft between the tanks, running at 800 rev. per min. They handle the contents of a tank in 1 hr. 15 min. The pumps have solution-lubrication, and the runners and shaft last for two years. The runners, of the inclosed type, have given no difficulty in pumping thick or sandy slime, and have a much greater efficiency than open runners of the star type. Each pump requires 1.5 and each agitator 1 horse-power.

The agitator-arms, 6 by 8 in. in size, have 1-in. cast-iron rods

driven through them and projecting 6 in. These rods protect the bottom of the arms from wear by the sand settling in the bottom of the tank. The vertical shaft, which drives the cross-arms, is set in a step-box bolted to the bottom of the tank, and the casting to which the cross-arms are bolted is faced to fit

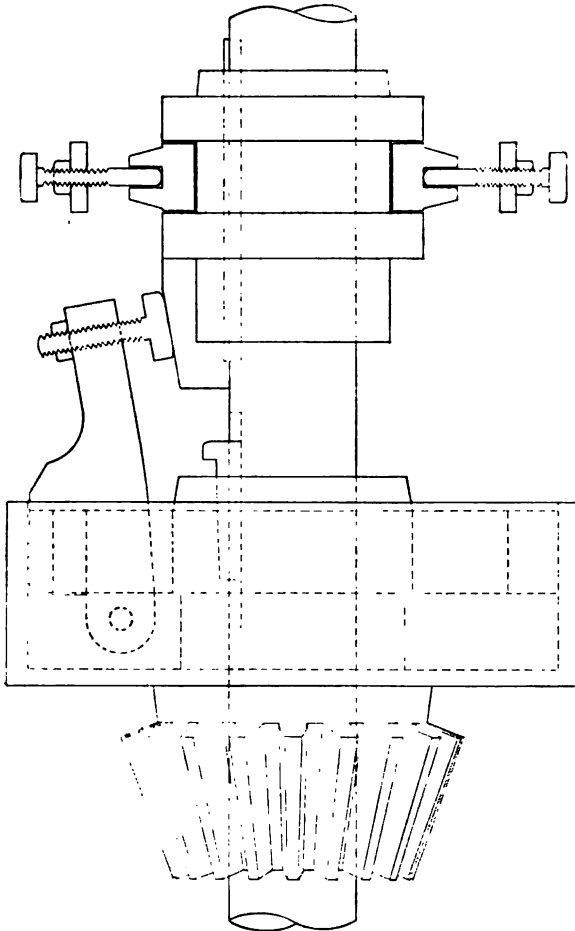


FIG. 8.—SPECIAL CLUTCH OF HOME-MADE CONSTRUCTION.

the step-box. In this way no sand is able to enter the box, and all the boxes examined to date are in as good condition as when first installed.

The power for the slime-plant is supplied by an 80-h.p. slide-valve engine, which runs the agitators, the treatment-pumps, and the centrifugal pumps for the batteries and storage-tanks.

The pulp overflowing from the sand-collecting tanks is delivered by a 6-in. pipe, set on a 1-per cent. grade, to a box at the side of one of the 35-ft. slime-collecting tanks. At the opposite side of the tank is a slotted decanting-pipe, through which the overflow of solution passes to the second tank. From the second tank a similar pipe carries the solution to the battery-sump, whence it is returned to the battery-supply tank by the centrifugal pumps or a 6-in. steam pump.

The flow of solution from the batteries is approximately 60 tons per hour. With the two collection-tanks in series a clean overflow of solution is possible with the most slimy ore.

Slime charges are drawn from the collecting-tanks, at intervals depending on the time of treatment and the tanks available, by a 4-in. centrifugal pump running 1,200 rev. per min. This pump transfers a charge of 35 tons in 30 min. During the transference of a charge the agitators in the collection-tanks are revolved to prevent the slime from packing in the tank; these agitators are similar to those in the treatment-tanks, but turn 2 rev. per minute.

The charge, after transference from the collecting-tanks, is agitated with pump and stirrer, settled, and decanted. This operation is repeated, using weak precipitated solution. The number of treatments given varies with the ore. Practically all the gold is dissolved in from 4 to 6 hr. after the first agitation begins, while the silver dissolves slowly and quite uniformly whether the pulp is being agitated or not. For this reason short agitations are given and as much time as possible is devoted to settlement and decantation, the object of the agitations being chiefly to mix thoroughly the slime and solution.

The addition of oxygen from the air, necessary for the dissolution of metals by cyanide, is much better made to the clean solution before it is mixed with the slime, for it is much more soluble in clean solution than in a thick pulp, and therefore frequent additions of fresh solution are preferable to continued agitation of a thick pulp. This method has been found to give the best results, even after the necessity for thorough washing has been obviated by the installation of the filters.

Clean unoxidized ore, settled 12 hr., contains 55 per cent. of moisture. Mixed ore containing from 30 to 40 per cent. of oxi-

dized ore, settled the same time, contains from 60 to 70 per cent. of moisture. The presence of from 5 to 10 per cent. of fine sand in the slime greatly increases the rate of settlement, and at the same time decreases the amount of moisture in the pulp. Pulp during agitation has a specific gravity of from 1.18 to 1.21; after settlement and decantation it runs from 1.24 to 1.28.

There are ten tanks available for the treatment of slime; one is used as a supply-tank for the filters, and of the nine remaining, two are at present used for the treatment of slime accumulated during the last years of the pan-amalgamation plant. With the seven tanks remaining, 70 hr. are available for treatment, charging a tank every 10 hr. Four agitations are given, the first of 8 hr. and the three following of 4 hr. each, which allows time for four 12-hr. decantations and 2 hr. for the charging of the tank and the transference of the charge to the filter-supply tank. The transference is done by the same pump used in charging the treatment-tanks.

The results of the treatment of a typical charge of mixed ore in the slime-plant are shown in Table XIII. The data cover three periods, in which the ore and treatment have varied. In the first period, that of 1907, Table XIV., clean unoxidized ore was treated and weak solutions were used. In the second period,

TABLE XIII.—*Results of a Typical Treatment of Slime.*

Dry slime charged, 35.5 tons. Specific gravity of the pulp charged, 1.2.

Solution in charge, 92 tons.

Agitation by means of pump and stirrer.

Solution added at beginning of each treatment is precipitated solution.

Agitation.												Decantation.					
Assay Pulp, Beginning of Agitation.												Assay Decanted Solution.		Assay Pulp, End of Agitation.			
Solution Strength.				Residue.		Undissolved.				Undissolved.							
Time.	KCN.	CaO.	Gold.	Silver.	Gold.	Silver.	Time.	Quantity.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.			
															Per Cent.	Per Cent.	Oz. per Ton.
8	0.09	0.07	0.25	8.8	0.14	5.7	12	27	0.085	2.5	0.04	2.3					
4	0.10	0.05	0.19	7.0	0.02	1.7	12	28	0.060	2.4	0.04	1.5					
4	0.11	0.04	0.18	5.2	0.01	1.4	12	30	0.045	1.4	0.01	1.3					
4	0.10	0.04	0.08	3.8	0.01	1.5	14	32	0.026	1.0	0.01	1.1					
Discharge to filters.....			0.04	2.8	0.01	1.1	...	...	0.027	1.0							

TABLE XIV.—*Results of Operations at the Slime-Plant.*

1907. Month.	Dry Slime.	Solution Ratio.	Strength of Solution.		Charging.		Discharge.		Extraction.	
			KCN.	CaO.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
	Tons.		Per Cent.	Per Cent.	Oz. per Ton.	Oz. per Ton.	Oz. per Ton.	Oz. per Ton.	Per Cent.	Per Cent.
March ..	1,677	6.0	0.130	0.018	0.434	10.7	0.01	1.06	97.7	90.07
April.....	1,640	5.3	0.135	0.027	0.291	9.1	0.01	1.08	96.3	86.7
May.....	1,766	5.2	0.124	0.030	0.337	7.3	0.01	1.12	96.7	84.6
June.....	1,686	6.8	0.103	0.014	0.291	5.7	0.01	0.08	96.5	85.8
July.....	2,065	5.4	0.098	0.006	0.308	5.1	0.01	0.96	96.7	81.3
August..	2,197	5.0	0.106	0.006	0.144	4.8	0.012	1.53	91.4	72.2
Total.....	11,031				0.294	6.83	0.01	1.11	96.6	83.6
With silver at \$0.50					\$9.49		\$0.76		91.9 Per Cent.	

1908.										
Feb.....	2,145	3.91	0.109	0.013	0.240	6.71	0.01	2.05	91.9	69.3
March.....	2,206	4.89	0.113	0.020	0.402	7.15	0.01	2.07	97.6	71.0
April.....	2,459	4.5	0.124	0.019	0.318	6.56	0.02	1.65	93.6	74.7
May.....	2,307	5.5	0.099	0.007	0.272	6.90	0.01	2.02	96.3	70.6
June.....	2,142	5.31	0.097	0.008	0.338	7.32	0.02	1.89	94.0	74.1
July.....	2,393	5.0	0.086	0.009	0.339	8.05	0.025	2.25	92.5	72.0
Total.....	13,652				0.318	7.12	0.0.6	1.99	94.9	72.0
With silver at \$0.50					\$10.13		\$1.32		86.9 Per Cent.	

1909.										
March...	2,648	4.0	0.191	0.029	0.246	7.6	0.010	1.15	95.9	84.8
April.....	2,878	3.8	0.156	0.036	0.275	7.2	0.010	1.23	96.3	84.7
May.....	2,853	4.0	0.144	0.045	0.222	6.9	0.011	1.26	95.0	81.7
June.....	2,747	4.0	0.108	0.083	0.262	7.6	0.012	1.30	95.4	82.8
Total.....	11,126				0.251	7.4	0.011	1.24	95.6	83.2
With silver at \$0.50					\$8.88		\$0.84		90.5 Per Cent.	

that of 1908, a large amount of unoxidized ore was treated, the strength of the solutions remaining the same. The last period is for 1909, oxidized ore being treated, but with a solution stronger in cyanide. In this latter period the work of the filters is shown.

A comparison of the cost of slime-treatment before and after the installation of filters is given in Table XV.

3. Filters.

The filter-plant has two Oliver continuous filters, each of 60 tons capacity. These filters consist of drums, 11 ft. 6 in. in diameter by 8 ft. wide, revolving on horizontal axes in boxes or tanks. The outer surface of the drums is divided into sec.

TABLE XV.—*Cost of Treatment of Slime.*

Item.	Before Installation of Filters. Cost Per Ton of Slime Treated.	After Installation of Filters, Cost Per Ton of Slime.	
		Slime-Plant.	Filters.
Native labor.....	\$0.0803	\$0.0890	\$0.0372
Supervision.....	0.0513	0.0497	0.0215
Cyanide.....	0.6007	0.3434	.....
Lime.....	0.1710	0.1035	.....
Pumps, piping.....	0.0036	0.0013	0.0012
Belts, lacing.....	0.0085	0.0084	0.0067
Lubricant.....	0.0088	0.0022	0.0033
Miscellaneous	0.0364	0.0099	0.0066
Total.....	\$0.9606	\$0.6074	\$0.0765
Power.....	0.2534	0.1419	0.0835
		0.7493	0.1600
Total.....	\$1.2140	\$0.9093	
Tons treated.....	17,540	11,126	

tions and covered with the filtering-medium. The drums are partly submerged in the pulp to be filtered (kept from settling by air-agitation) and, as they revolve, a vacuum applied to the sections builds up a cake of slime on the surface. As the sections leave the pulp they are dried by the vacuum and then a water-wash is applied and drawn through the slime. Just before the section enters the pulp again, air, under pressure, is admitted to the chamber and the cake is discharged. The cycle is then repeated, the whole work being continuous and automatic.

The construction of the filters is shown in Figs. 9 and 10. The drum is built of 3.5-in. staves firmly bolted to the spiders. The perimeter of the drum is divided into 24 sections by 1-in. strips. Small strips, 0.5 by 0.5 in., nailed 1 in. apart, form channels for the passage of solution in each section. Two 0.5-in. pipes are connected to each section, which pass through the hollow shaft supporting the drum to a plate at the end.

The plate has two circles of 24 holes each, to which the pipes are connected. Facing this plate is a second plate, having a groove or channel opposite the outer circle of holes. An adjustable bridge in this groove covers one hole, so that, the channel being connected to the vacuum-pumps, a vacuum is

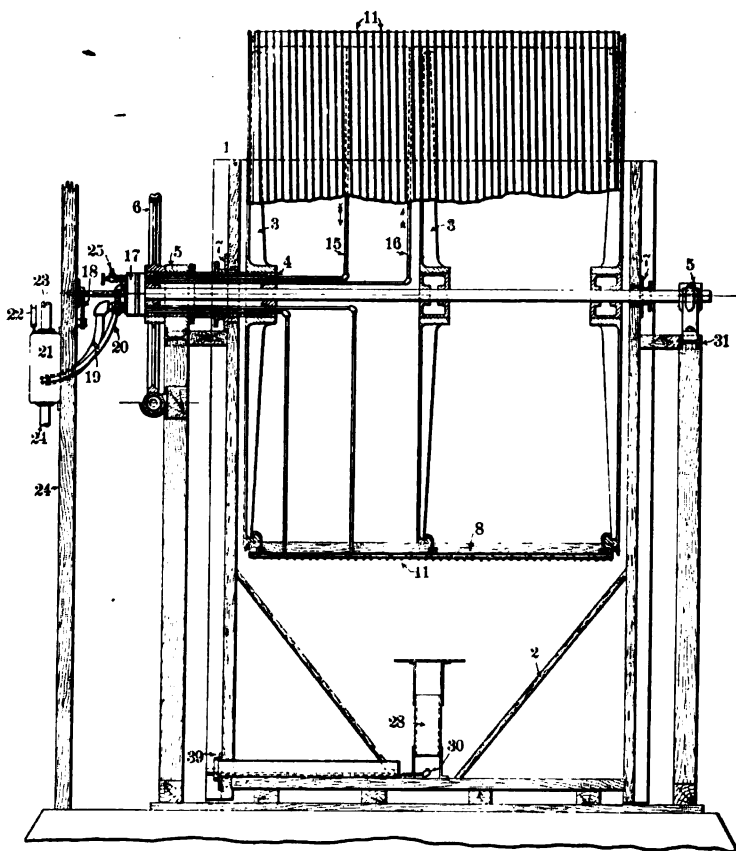


FIG. 9.—OLIVER CONTINUOUS FILTER. TRANSVERSE SECTION AND ELEVATION.

- | | |
|--|---|
| 1. Redwood tank. | 11. Steel-wire protection for filter medium. |
| 2. False bottom. | 12. Steel scraper. |
| 3. Cast-iron spiders supporting filter-drum. | 13. Adjusting-screw and lever for scraper. |
| 4. Hollow trunnion carrying spiders, piping, etc. | 14. Tailings-apron. |
| 5. Main bearings. | 15. Vacuum-pipes from filter-sections to automatic valve. |
| 6. Worm-drive gear. | 16. Pressure-pipes from filter-sections to automatic valve. |
| 7. Stuffing-boxes. | 17. Automatic valve. |
| 8. Redwood staves for filter-drum. | 18. Adjusting-lever for valve. |
| 9. Filter medium. | |
| 10. Division-strips dividing filter into sections. | |

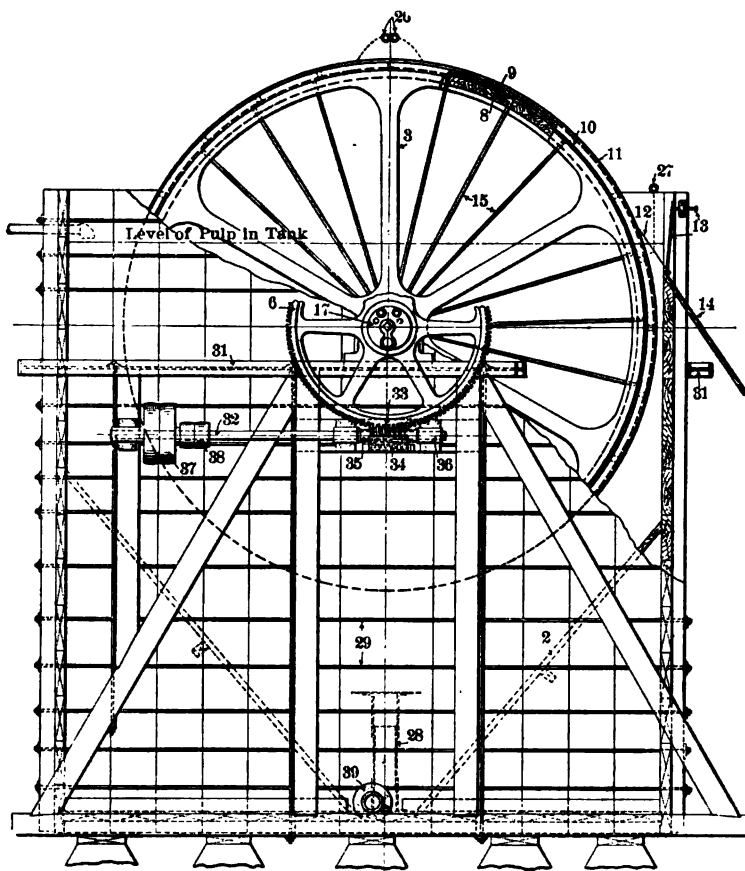


FIG. 10.—OLIVER FILTER. LONGITUDINAL SECTION AND ELEVATION.

- | | |
|---|------------------------------------|
| 19. Flexible vacuum-hose for working- | 28. Agitator-pipe. |
| solution. | 29. Tie-rods. |
| 20. Flexible vacuum-hose for wash-solu- | 30. Agitating air-nozzle. |
| tion. | 31. I-beam frame. |
| 21. Vacuum-chamber containing float | 32. Worm-shaft. |
| check-valve. | 33. Worm. |
| 22. Vacuum-gauge. | 34. Oil-well for worm. |
| 23. Pipe to dry-vacuum pump. | 35. Thrust-collars for worm. |
| 24. Pipe to solution-pump. | 36. Post-bearings for worm-shaft. |
| 25. Pressure-pipe for blowing filter-sec- | 37. Driving-pulleys. |
| tions. | 38. High-speed pulleys for wiring. |
| 26. Wash spray-pipe. | 39. Flange for drain. |
| 27. Discharge spray-pipe. | |

applied to 23 of the sections. Air under pressure, passing through the pipe connected to the inner circle of holes in the plate, is admitted to the section that is cut off from the vacuum by the bridge. As the drum revolves the vacuum is cut off from each section in turn and air is admitted.

A screen is placed on the strips forming channels in the sections. The strips dividing the drum into sections are planed level with the surface of the screens. A layer of burlap covers the screens and on this the canvas is placed. The canvas is drawn tight and calked into a groove around the edge of the drum. To bind the canvas firmly to the division-strips, the drum is wound with spring-steel wire. The wiring makes each section tight and prevents the canvas from bulging when the cake is discharged.

The drums are submerged for three-fifths of a revolution. Every section as it enters the pulp is connected to the vacuum-pumps. As the drum revolves the section picks up a cake of slime and, upon leaving the pulp, this cake is dried by the vacuum. A water-wash is then applied in the form of a drip, in much the same manner as clean water is added in cleaning the concentrate on a vanner. This water is drawn through the cake until the vacuum is cut off and the cake discharged. The discharge takes place just before the section enters the pulp for a repetition of the cycle. The drums revolve once every 4 min.

The air and solution from the sections go to a chamber that is connected to the wet- and dry-vacuum pumps. Here the solution and air are separated, the wet-vacuum pump being connected to the base of the chamber, the dry-vacuum pumps to the top.

Two one-cylinder dry-vacuum pumps and one double-cylinder solution-pump are used. (These wet- and dry-vacuum pumps have been displaced by a wet-vacuum pump which maintains a 26-in. vacuum and takes less power.) A small compressor furnishes air at from 5 to 10 lb. pressure to discharge the slime and agitate the pulp in the filter-boxes. To operate the pump, compressor, and drums, 13 h.p. are required. With this equipment the capacity of the filters is 125 tons of dry slime per day.

The vacuum, maintained at 25 in., yields a cake of slime varying from $\frac{3}{16}$ to $\frac{3}{8}$ in. thick, depending on the character of

the slime filtered. Between the time a section leaves the pulp and the application of the water-wash, the slime is dried to 35 per cent. of moisture. The amount of water drawn through the cake is practically equal to the moisture in the slime. As the pulp ordinarily filtered has a specific gravity of 1.24, the amount of solution passed through the filters is large, the ratio of solution to slime in the pulp being 2.8 to 1.

In treating oxidized ore, 33 per cent. of moisture is discharged in the residue, which is chiefly clay having the character of a colloid. A certain quantity of tailings from the former pan-amalgamation plant has been re-treated in the slime-plant. These tailings contained a large amount of fine sand from the pans, and the filters reduced the moisture in this material to 25 per cent.

The water-wash almost completely displaces the gold, silver, and cyanide in the cake. The quantity of cyanide discharged is from 0.1 to 0.8 lb. per ton of dry slime. The undissolved content of the slime filtered is practically equal to the content of the discharged residue, the difference between the two being 0.1 oz. of silver.

The lime in the solutions gradually deposits in the cloth and cuts down the capacity of the filters. To rectify this, the cloth is washed once every two weeks with dilute hydrochloric acid. The washing takes an hour, and 7 lb. of acid is used in treating one drum.

There is 290 sq. ft. of filter-surface on each drum. Filtering 60 tons per day, per drum, each square foot handles 400 lb. of dry slime. The canvas lasts from three to five months. To re-cover and re-wire a drum takes from 12 to 18 hours.

The cost of re-covering a drum is:

13 yd. No. 12 duck, 104 in. wide,	\$14.48
25 yd. 8-oz. burlap,	2.65
77 lb. No. 17 spring-steel wire,	6.70
Mechanic and 3 <i>peones</i> , 16 hr.,	10.00
Total,	<u>\$33.83</u>
Tons filtered by cloth,	4,000
Cost per ton filtered,	\$0.0084

One *peon* attends the filters and machinery, an expense which would not be necessary in the United States, where labor is efficient, since the greater part of the time no attention is needed beyond the oiling of the machinery.

The cost of the operation of the filters given in connection with the slime-plant includes a proportion of the charges for supervision of mill, shiftmen, time-keeper, watchmen, and shop-charges for mill. The direct cost of operation per ton of dry slime filtered, not including pro rata supervision, etc., is :

Labor,	\$0.0161	
Covering drum, material,	0.0060	
Covering drum, labor,	0.0022	
Repairs and supplies,	0.0112	
Lubricant,	0.0033	\$0.0388
Power,		0.0835 ^a
Total,		\$0.1223

^a Filters running under capacity.

In Table XVI. the results of operations at the filtering-plant for a period of four months are given. During this time the amount of slime filtered was less than the capacity of the filters.

TABLE XVI.—*Results of Operations at the Filtering-Plant.*

Quantity of Dry Slime.	Charging.		Solution Recovered.				Discharge Residue.		
	Undis- solved.	Residue.	KCN.	CaO.	Gold.	Silver.	Gold.	Silver	
	Silver.	Silver.							
	Tons.	Oz. Per Ton.	Oz. Per Ton.	Per Cent.	Oz. Per Ton.	Oz. Per Ton.	Oz. Per Ton.	Oz. Per Ton.	Oz. Per Ton.
2,648	1.10	2.13	0.152	0.02	0.020	0.83	0.010	1.15	
2,878	1.25	2.49	0.128	0.02	0.023	1.01	0.010	1.23	
2,853	1.09	2.78	0.117	0.03	0.025	1.03	0.012	1.24	
2,747	1.17	2.80	0.086	0.02	0.026	1.06	0.012	1.30	
11,126	1.15	2.55	0.120	0.02	0.023	0.98	0.011	1.24	
									\$0.85

Figs. 11, 12, and 18 are photographic views of an Oliver 50-ton continuous filter operated by the North Star Mine Co., Grass Valley, Cal., which illustrate the manner of removing the slime from the drum.

4. *Precipitation.*

The solutions from the sand- and slime-plants are collected in sumps situated at the foot of the plant. Centrifugal pumps deliver the solution for precipitation to two tanks placed above the precipitation-room, which is 40 by 80 ft. in area. A plan of



Fig. 11.—The 50-Ton Oliver Filter of the North Star Mines Co., Grass Valley, Cal.

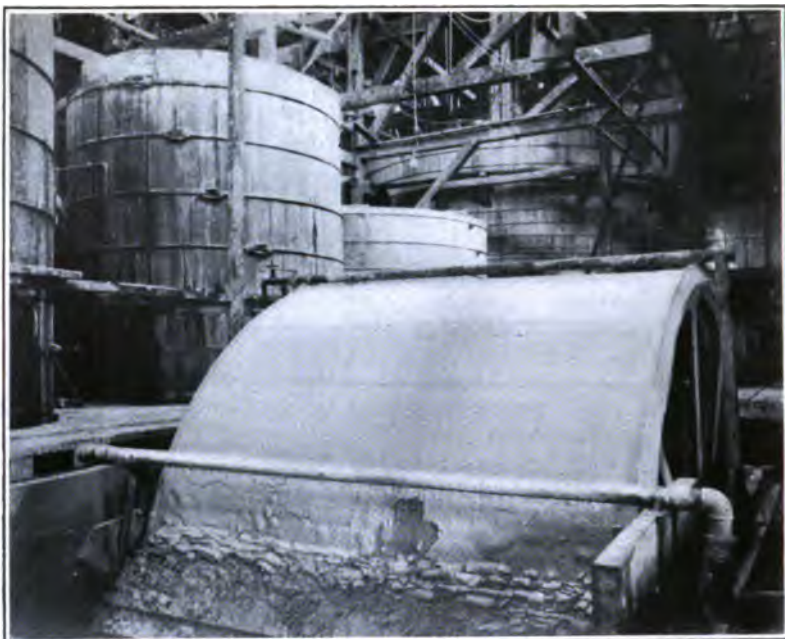


FIG. 12.—THE 50-TON OLIVER FILTER OF THE NORTH STAR MINES CO., GRASS VALLEY CAL., SHOWING THE REMOVAL OF CAKED SLIME BY SCRAPER.

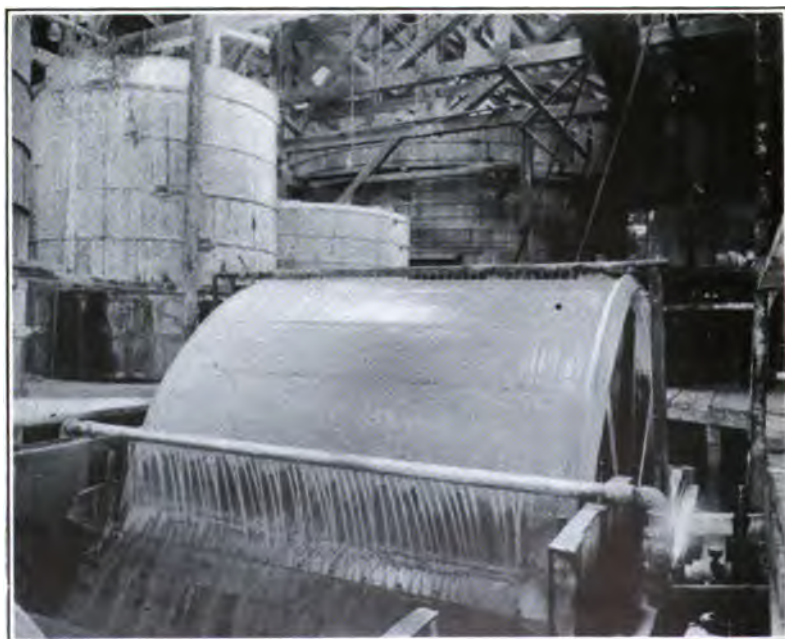


FIG. 13.—THE 50-TON OLIVER FILTER OF THE NORTH STAR MINES CO., GRASS VALLEY, CAL., SHOWING THE REMOVAL OF CAKED SLIME BY WATER-SPRAY.

this room, showing the position of the zinc-boxes, furnaces, etc., is given in Fig. 14. Along one side of the room are zinc-precipitation boxes of two types, arranged as shown on Fig. 15; 8 are of sheet steel, having 10 compartments, 12 by 22 by 27 in.; 6-mesh screens are placed 5 in. above the bottom. The bottoms are hopper-shaped and discharge through 2-in. iron cocks to the clean-up launder, which delivers the solution and precipitate to the sump situated in the middle of the room on the side containing the boxes.

Two pairs of wooden boxes are placed on the other side of the sump, each having five compartments, 24 by 24 by 22 in., and one compartment, 12 by 24 by 22 in., used for settling. The

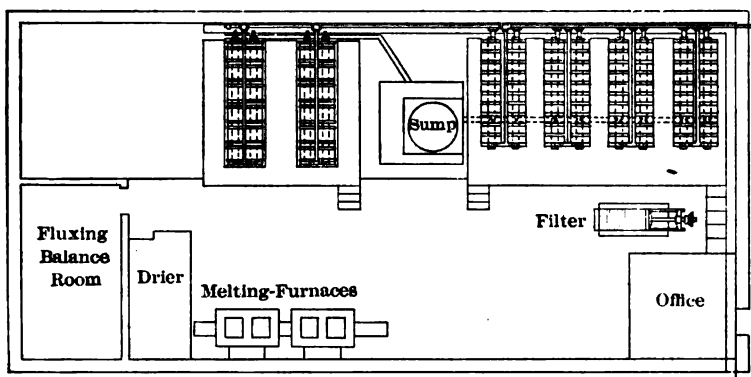


FIG. 14.—PLAN OF PRECIPITATION-ROOM, SHOWING THE POSITION OF ZINC-BOXES, FURNACES, ETC.

boxes have one side in common. The bottom slopes to the side, the precipitate being delivered to the sump by a launder along the side of the box. These boxes have 4-mesh screens placed 5 in. above the bottom. Both sets of boxes are set 3 ft. above the concrete floor, which is drained to a sump. The precipitated solutions flow to two tanks at the side of the building.

The precipitate is delivered on to a screen over the clean-up tank, which is of redwood, 6 ft. in diameter by 4 ft. deep, and is fitted with a canvas filter. This tank drains into the sump, above which it is placed. The solution obtained from the clean-up is pumped by a 2-in. steam-pump to a 24-in. Shriver filter-press, holding 24 frames, each 1 in., the effluent solution from which goes to the head of the low-grade extractors. The

precipitate is settled in the tank, drained over night, and put into the drier:

The drier consists of a steel box with cast-iron plates for a base, resting on a flue shaped like the letter U. The flames from a small fire-box at one end thus pass twice the length of the drier before reaching the stack. A small fire serves to dry from four to eight trays of precipitate, weighing from 440 to 1,000 lb., in five hours.

On the side of the room facing the precipitation-boxes are two pairs of melting-furnaces, each 18 in. in diameter and 26 in. deep. There is a stack for each pair of furnaces, natural draft alone being used.

Two grades of solution are precipitated. The high-grade solution, consisting of the first drainings from sand-plant, runs from 3.5 to 4.5 oz. of silver and from 0.15 to 0.25 oz. of gold per ton. Six of the steel boxes are used to receive this solution. Nine of the 10 compartments are filled with zinc; the last compartment being used as a settler. Each set of boxes contains 30 cu. ft. of zinc-shavings. The rate of flow of solution has varied from 1.1 to 2.7 tons of solution per 24 hr. per cubic foot of zinc; the precipitation is good at a rate up to 3 tons per cubic foot of zinc; above this rate it falls off.

The low-grade solution comprises the intermediate washes from the sand and the first decantations from the slime. These solutions carry from 1 to 2 oz. of silver and from 0.03 to 0.06 oz. of gold per ton. The solution coming from the slime-plant was until recently sent to the extractors without filtering. This gave no trouble and the precipitate was of good grade; but in order to avoid a slow accumulation of slime in the sump the solution is now filtered.

The low-grade solutions are precipitated in two of the steel and two of the wooden boxes. The wooden boxes are more convenient and easier to clean. The size of the compartments is more suitable for a silver solution than the smaller ones of the steel boxes. The rate of flow for the wooden boxes has varied from 4 to 8 tons of solution per 24 hr. per cubic foot of zinc. The precipitation takes place almost entirely in the first two compartments, the solution having ample cyanide for good precipitation.

An interesting feature of the work is the regeneration of

cyanide. As will be seen from Tables XVII. and XVIII., the cyanide-strength of the solution leaving the boxes is greater than that of the entering solution. Drip-samples, taken at the head and foot of the boxes, have shown a regeneration of cyanide for a period of two years, due to the lime present, which reacts with the zinc in solution, forming zinc hydrate and liberating the cyanide.

TABLE XVII.—*Results of Precipitating High-Grade Solutions.*
(Monthly Averages.)

Date.	Incoming Solution.				Outgoing Solution.				
	KCN.	CaO.	Gold.	Silver.	KCN.	CaO.	Gold.	Silver.	Silver Precipitate.
	Per Cent.	Per Cent.	Oz. Per Ton.	Oz. Per Ton.	Per Cent.	Per Cent.	Oz. Per Ton.	Oz. Per Ton.	Per Cent.
Sept., '08.....	0.137	0.015	0.150	3.19	0.150	0.020	0.002	0.020	99.3
Oct., '08.....	0.136	0.038	0.182	3.57	0.154	0.059	0.002	0.017	99.5
Nov., '08.....	0.143	0.074	0.179	3.40	0.161	0.083	0.003	0.020	99.4
Dec., '08.....	0.124	0.069	0.210	3.76	0.142	0.071	0.002	0.033	99.1
Feb., '09.....	0.184	0.027	0.155	2.82	0.192	0.031	0.001	0.040	97.9
Mar., '09.....	0.215	0.025	0.163	3.69	0.224	0.025	0.002	0.047	98.7
Apr., '09.....	0.210	0.047	0.161	4.46	0.222	0.052	0.002	0.080	98.2
May, '09.....	0.170	0.052	0.153	4.13	0.181	0.060	0.002	0.032	99.2

TABLE XVIII.—*Results of Precipitating Low-Grade Solutions.*
(Monthly Averages.)

Date.	Incoming Solution.				Outgoing Solution.				
	KCN.	CaO.	Gold.	Silver.	KCN.	CaO.	Gold.	Silver.	Silver Precipitate.
	Per Cent.	Per Cent.	Oz. Per Ton.	Oz. Per Ton.	Per Cent.	Per Cent.	Oz. Per Ton.	Oz. Per Ton.	Per Cent.
Sept., '08.....	0.102	0.021	0.027	0.81	0.103	0.020	0.001	0.05	93.8
Oct., '08.....	0.103	0.026	0.037	1.01	0.103	0.027	0.001	0.05	95.0
Nov., '08.....	0.125	0.035	0.040	1.01	0.128	0.031	0.001	0.06	94.0
Dec., '08.....	0.105	0.028	0.035	0.90	0.110	0.029	0.001	0.04	95.5
Feb., '09.....	0.155	0.023	0.044	1.00	0.160	0.024	0.001	0.09	91.0
Mar., '09.....	0.167	0.032	0.040	1.14	0.191	0.029	0.001	0.13	88.5
Apr., '09.....	0.156	0.035	0.034	1.44	0.156	0.036	0.001	0.17	88.2
May, '09.....	0.143	0.044	0.033	1.40	0.147	0.045	0.001	0.09	93.5

The slight variation of the plant-solution after two years' use is shown in Table XIX. The first analysis was made after the plant had been running three weeks and the solutions were fresh; the others follow at intervals of six months. For all practical purposes the solutions have remained the same. The in-

crease in oxidized ore carrying organic matter accounts for the increase in reducing-power.

TABLE XIX.—*Composition of the Plant-Solution.*

Date.	March, 1907.		Sept., 1907.		Sept., 1908.		March, 1909.	
	A.	B.	A.	B.	A.	B.	A.	B.
Gold, oz. per ton.....	0.120	0.001	0.158	0.002	0.150	0.002	0.163	0.002
Silver, oz. per ton.....	3.06	0.05	3.05	0.02	3.19	0.02	3.69	0.04
KCN, per cent.....	0.180	0.220	0.120	0.130	0.137	0.150	0.215	0.224
Protect. CaO, per cent.	0.024	0.040	0.035	0.042	0.015	0.020	0.025	0.025
Total CaO, per cent....	0.132	0.164	0.105	0.105	0.103	0.124	0.180	0.210
Reducing-power.....	0.730	0.860	0.540	0.600	0.340	0.313	0.619	0.561
Ferrocyanide, per cent.	0.018	0.022	0.060	0.072	Nil.	Nil.	Nil.	Nil.
Copper, per cent.....	0.038	0.018	0.038	0.017	0.014	0.002	0.019	0.008
Zinc, per cent.....	0.065	0.084	0.036	0.045	0.027	0.045	0.038	0.068

A. Strong plant-solution after passing through the sands.

B. Same solution after precipitation.

During 1907 caustic soda was used as the neutralizing agent, and coincident with its use there developed a considerable amount of ferrocyanide in the solution. Upon changing to the use of lime alone the amount of ferrocyanide dropped and is now *nil*. Furthermore, lime prevents the fouling of the solution by iron, precipitating it as ferric hydrate. It also has the advantage of being a good settling-agent for the slime.

The boxes are cleaned up each week. Half the strong and half the weak boxes are cleaned one day, the remainder three days later. The boxes are all dressed with zinc on clean-up days. Two natives attend to this work. The flow of solution being stopped, the coarse zinc remaining in the head-compartment is rinsed in the compartment and transferred to a tub of water. When the coarse zinc has been removed, the solution and precipitate are discharged into the launder. A layer of new zinc is placed on the screen and the washed zinc returned. The compartments are cleaned in rotation, the zinc removed going first to fill the head-compartment, and then the others in order. When all the zinc has been returned, there remain two or three compartments empty, which are filled with fresh zinc and the flow of solution started. The overflow is clear on starting the boxes.

The fine zinc and precipitate is delivered by the launder to a No. 40 brass screen over the clean-up tank. The fine precipitate passing the screen settles on the filter-cloth and the

rate of filtration decreases. To avoid delay from this cause, the excess solution arising from the washing of the zinc is pumped from the top of the tank to a filter-press.

The fine zinc remaining on the screen is well washed with water and returned to the head-compartments of the zinc-boxes. In two years there has been no accumulation of short zinc.

The precipitate in the tank is drained over night and the following morning is placed in the drier. About 95 per cent. of the clean-up is obtained from the tank, the remainder passing to the filter-press. The press is cleaned bi-monthly, the product amounting to about 250 kg. An hour is sufficient to clean the tank and place the product in the drier. To clean the press properly takes from 4 to 6 hr. A set of cloths for the press costs \$26, while the filter in the tank costs \$3. The durability is approximately the same, from eight to ten months. The amount of precipitate obtained each week is approximately 1,000 pounds.

When all solutions were filtered before precipitation the percentage of fine metal in the precipitate was 69.2 per cent. for a period of five months. The average of the succeeding five months, during which period 20,000 tons of solution were sent to the extractors without filtering, was 66.6 per cent.

5. *Melting.*

Four furnaces, 18 in. in diameter by 26 in. deep, are used for melting the precipitate, using No. 80 Dixon and No. 100 Battersea crucibles. The fuel is a mixture of 3 parts charcoal to 1 of coke. Natural draft is used, giving ample heat. The crucibles are handled with a lever hung from an overhead track serving the four furnaces. Two natives, working from 12 to 16 hr., flux and melt the week's clean-up into bars.

The dried precipitate is broken up and bedded on a zinc-lined table and the flux added. The flux consists of: ground borax-glass, 20; assay-slag, 6, and sand, from 2 to 4 per cent. The fluxed precipitate is put in manila-paper bags for charging into the pots.

The fires are started the first thing in the morning, and after the crucibles are hot they are filled with the precipitate. As the charge subsides more is added till the charge is fluxed.

This usually takes from an hour to an hour and a half. A melt requires an additional hour. The pours are made into conical molds, the slag obtained being practically as glassy as the average assay-slag and free from shot.

The melts are arranged to give from 15 to 20 kg. of bullion, two melts going to make a bar. The bullion from the cones has a thin skin of matte, soft and malleable. The cones of bullion are remelted with borax-glass and iron, the amount of iron used depending on the quantity of matte on the bullion. The iron serves to make a matte which is easily removed from the bars, and at the same time reduces the value of the matte by replacing some of the silver. The melted bullion is skimmed till clean, thoroughly stirred, two dip-samples taken, and then poured into molds. The bars are cleaned with dilute sulphuric acid. The average fineness of gold and silver during 1908 was 932.

The dip-samples are bored and the borings used for the assays. Much more reliable and concordant results are obtained than when the dip-samples are poured into water or the bars bored.

The skimmings from the bars are remelted with addition of excess of iron and 10 per cent. of sodium bicarbonate. Clean slag, matte, and bullion are obtained, the bullion separating cleanly from the matte. The quantity of matte obtained in a year is small, amounting to about 500 lb. The composition of the matte before remelting is: Ag, 45.8; Au, 0.2; Cu, 20.9; Fe, 2.8, and Pb, 8.6 per cent.

After remelting with addition of iron the average analysis is: Ag, 11.84; Au, 0.013; Cu, 18.0, and S, 22.4 per cent.

Due chiefly to the fact that no acid is used in treating the precipitate, the slag formed is not corrosive. Crucibles are used for 20 or 25 melts without relining. Old crucibles are cleaned and ground up. The graphite thus obtained is mixed with solution of sugar till it has the consistency of molding-sand and is used in relining the crucibles. A lining 0.5 in. thick is tamped in cleaned crucibles and then slowly dried. After thorough drying and annealing the relined crucibles are good for 10 more melts. The work is done by the men employed in the melting-room.

A portion of one typical clean-up was carefully sampled and assayed. The bullion, slag, and matte were likewise analyzed. The composition of the precipitate was:

	Per Cent.
Silver,	67.71
Gold,	2.62
Copper,	7.43
Zinc,	4.81
Lead,	2.12
Sulphur (combined),	0.39
SiO ₂ ,	6.28
CaCO ₃ ,	5.54
Fe ₂ O ₃ ,	1.84
Al ₂ O ₃ ,	0.73
MgCO ₃ ,	0.13
KCN, NaCN,	traces
Organic matter, undetermined.	
Total,	99.60

The precipitate before melting contained 8.03 per cent. of moisture.

The results of melting were:

	Ounces.
Dry weight of precipitate melted,	5,363.9
Ground borax-glass,	1,220
Assay-slag,	450
Sand,	375
Total,	7,408.9

The recovery of the precious metals was as follows:

		Ag. Ounces.	Au. Ounces.
5,363.9 oz. precipitate . {	67.71 per cent. Ag =	3,631.89	
	2.62 per cent. Au =		140.53
4,097.5 oz. bullion, . {	87.27 per cent. Ag =	3,566.09	
	3.37 per cent. Au =		138.08
3,156.0 oz. slag, . {	0.96 per cent. Ag =	30.29	
	0.032 per cent. Au =		1.01
43.4 oz. matte, . {	19.11 per cent. Ag =	8.29	
	0.059 per cent. Au =		0.025
Total recovery,		3,604.67	139.115
Percentage of recovery,		99.25	99.01

The composition of the slag was :

	Per Cent.
Ag	0.96
Au	0.03
CuO	1.52
FeO	2.57
Al ₂ O ₃	5.64
CaO	7.24
MgO	2.13
PbO	7.36
SiO ₂	23.40
ZnO	8.51
S	0.23
Na ₂ O	13.20
Br ₂ O ₃	29.74

The analysis of the matte was :

	Per Cent.
Ag	19.11
Au	0.059
Cu	22.95
Fe	31.64
S	23.40
Zn	1.68

The costs of precipitation and melting, Table XX., are given together, as the work is interdependent. Two men are employed in the work, cleaning the boxes and melting. The zinc is cut in the machine-shop, and the cost of cutting is included in the labor and power items.

TABLE XX.—*Cost of Precipitation and Melting.*

	Per Ton of Ore.	Per Fine Ounce, Gold and Silver.
Labor,	\$0.0174	\$0.0032
Supervision,	0.0168	0.0030
Zinc,	0.0800	0.0111
Coke,	0.0055	0.0010
Charcoal,	0.0053	0.0009
Borax-glass,	0.0158	0.0029
Crucibles and covers,	0.0044	0.0006
Power,	0.0017	0.0003
Miscellaneous supplies,	0.0030	0.0005
Total,	\$0.1299	\$0.0235

These figures in Table XX. are the average for a period of seven months, during which time 224,390 fine ounces of gold and silver were precipitated and melted.

The returns from the mill-treatment of both unoxidized and oxidized ores are given in Table XXI.

TABLE XXI.—*Mill-Returns on Unoxidized and Oxidized Ores.*

1907. Month.	Quantity Milled.	Unoxidized Ore.							
		Assay of Heads.		Quantity Present.		Quantity Recovered.		Recovery.	
		Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
	Tons.	Oz. per Ton.	Oz. per Ton.	Oz.	Oz.	Oz.	Oz.	Per Cent.	Per Cent.
March.....	4,867	0.27	6.78	1,265.42	82,998.0	1,216.76	28,740.0	96.1	87.0
April.....	4,540	0.20	6.2	908.00	28,148.0	862.60	28,184.7	95.0	85.9
May.....	4,966	0.21	5.7	1,040.00	28,249.0	991.20	23,909.5	95.2	84.6
June.....	4,876	0.21	5.1	1,028.96	24,887.6	975.20	20,978.3	95.2	84.3
July.....	5,400	0.21	4.1	1,134.00	22,140.0	1,080.00	17,678.3	95.2	79.8
August.....	5,277	0.17	4.9	897.09	25,857.3	889.20	18,669.0	95.4	72.2
Total.....	29,916	0.209	5.42	6,269.23	162,259.9	5,964.96	134,159.8	95.1	82.6
With silver at \$0.50		\$7.08		\$210,714.98		\$190,375.62		90.3	

1908.		Oxidized Ore.							
		Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
February.....	5,190	0.206	5.43	1,069.14	28,181.7	1,017.24	20,907.1	95.1	74.1
March.....	5,541	0.255	5.75	1,412.95	31,880.7	1,358.91	24,165.8	96.0	75.6
April.....	5,989	0.213	5.63	1,265.00	33,486.5	1,181.02	27,568.4	93.3	82.4
May.....	5,207	0.208	6.22	1,088.05	32,887.5	1,031.01	24,528.0	95.2	75.5
June.....	5,187	0.240	6.39	1,244.88	33,144.9	1,141.14	25,741.4	91.6	77.6
July.....	5,878	0.245	6.60	1,438.88	38,761.8	1,321.42	25,926.9	91.6	66.8
Total.....	32,987	0.228	6.00	7,513.90	197,773.1	7,050.74	148,822.6	93.8	75.2
With silver at \$0.50		\$7.71		\$254,198.86		\$220,150.10		86.0	

1909.	Quantity Milled.	Oxidized Ore.					
		Assay of Heads.		Assay of Tails.		Recovery.	
		Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
	Tons.	Oz. per Ton.	Oz. per Ton.	Oz. per Ton.	Oz. per Ton.	Per Cent.	Per Cent.
March.....	5,838	0.258	6.60	0.015	1.15	94.02	82.49
April.....	5,923	0.258	6.73	0.015	1.31	94.14	80.44
May.....	6,043	0.242	6.81	0.016	1.28	93.38	81.15
June.....	6,082	0.245	7.01	0.016	1.30	93.38	81.42
Total.....	23,886	0.251	6.79	0.016	1.26	93.62	81.44
With silver at \$0.50		\$8.58		\$0.96		88.81	

X. COST OF MILLING AND CYANIDING.

The total cost for the year 1908 was approximately \$1.50 per ton. So far during 1909 the cost per ton is lower, largely due to an increased saving in cyanide made by the filters and to better quality of wood and cyanide. Included in the labor, salaries, and miscellaneous items are the charges for work done in the shops for the mill. Half the cost of the assay-office is included in the items given below :

	Per Ton of Ore.
Labor,	\$0.3053
Salaries,	0.1265
Wood,	0.3205
Cyanide,	0.3005
Lime,	0.0926
Zinc,	0.0682
Shoes and dies,	0.0591
Lubricant,	0.0143
Borax,	0.0110
Coke and charcoal,	0.0112
Assay-supplies,	0.0047
Crucibles,	0.0041
Fittings,	0.0032
Screens,	0.0013
Miscellaneous,	0.0497
Total,	<u>\$1.3722</u>

Borax-Deposits of the United States.

Discussion of the paper of Charles R. Keyes, presented at the Spokane meeting.
Bulletin No. 34, October, 1909, pp. 867 to 903.

A. M. STRONG, Bishop, Cal. (communication to the Secretary*):—The paper of Mr. Keyes gives us the most complete account of the geology of the borax-deposits in the Death Valley region that has yet been published, and is a valuable addition to the geological literature of a very interesting though little-known territory. During the past ten years I have been over much of the northern part of the country described by Mr. Keyes and the region immediately north of it.

Mr. Keyes seems to give the impression that Furnace creek is the northern end of these borate-bearing deposits, but such is not the case. Of the seven principal marsh-deposits which for years furnished the greater part of the borax supply in the manner described by him, four are north of the boundary-line as given on his map. The entire territory immediately east of the Sierra Nevada is composed of a series of sinks, each with a well-defined drainage-area. Of these, Death valley is the deepest, and its drainage-area one of the greatest. The section given in the paper is typical of any line drawn eastward from the Sierra Nevada. At the lowest point of each of these sinks is a marsh, which, in times of heavy rain-fall in the mountains, is converted into a lake. These marshes always contain borax, which is now considered to have been derived from the washing of the Tertiary lake-beds in the surrounding mountains, of which they form a considerable part. Additional territory which I have studied shows that the boundaries given on Mr. Keyes's map should be considerably extended to the north. Just how far these borate-beds extend I am not prepared to say. J. E. Spurr says of them :¹

* Received Nov. 1, 1909.

¹ *Professional Paper No. 55, U. S. Geological Survey, p. 161 (1906).*

" . . . these older colemanite beds are characteristic of the broad belt of earlier Tertiary sediments which runs northwest and southeast in the region lying immediately east of the Sierra Nevada and which reaches at least as far north as northern Nevada and as far south as the Mojave desert."

In the Tertiary sediments north of those outlined by Mr. Keyes, colemanite has been reported by W. H. Storms and others in Fish Lake valley, and I have found it within the Saline Valley drainage, although in neither place is it in paying quantities.

In the main, I agree with Mr. Keyes in regard to the general geology of the country, though there is not much data, as yet, on which to work, but I take exception to his statement (page 887):

"The borate-bearing deposits are usually spoken of as lake-beds. Upon what grounds I do not know. Lithologically, they appear to be the same from Death valley to the Pacific ocean. Only in the western part of the Mojave plain have fossils been found, and these are marine Eocene and Miocene types. It seems probable that if strictly marine beds extend this far from the Pacific into the Mojave area, the Death Valley beds are also deposits of the sea rather than of extensive lakes in the process of desiccation."

I consider that there is ample data on record to identify these deposits as fresh-water lake-beds.

Mr. Spurr says: ²

"The Tertiaries at Silver Peak contain remains of fresh-water mollusks, fish, and plants, as well as coal beds."

He then lists a number of specimens from within the Fish Lake Valley drainage-area. Later he says: ³

"Farther south, in the Funeral Range, at Furnace Creek, the writer observed upturned Tertiary strata resembling those at Silver Peak. The series is several thousand feet thick and rests unconformably upon Paleozoic limestones. The beds are conglomerates, clays, sandstones, and chemically precipitated limestones or travertine, which also occurs in the Tertiaries at Silver Peak. The Furnace Creek beds are often gypiferous, contain grass remains, and include also a bed of borate of lime, or colemanite. No fossils have as yet been found in them. These Tertiaries extend southward and are widely distributed. In and near the El Paso Range Mr. H. W. Fairbanks has described a series of tilted clays, sandstones, volcanic tuffs, and interbedded lavas. This series is at least 1,000 feet thick. A seam of coal occurs in these beds, near which are found fossil leaves which Doctor Knowlton regarded as probably Eocene. Farther south, in the Mojave Desert,

² *Professional Paper No. 55, U. S. Geological Survey*, p. 20.

³ *Op. cit.*, p. 21.

near Daggett, is a folded and faulted series of sandstones, shales, and tuffs more than 1,000 feet thick. The series overlies rhyolite and contains a bed of colemanite. Mr. W. H. Storms who has described this occurrence, regards the period of folding as perhaps Oligocene."

Sydney H. Ball, in speaking of this territory, says:⁴

"The Eocene inaugurated the Tertiary period of volcanism and lake sedimentation processes, accompanied by important deformation, erosion, and ore formation."

Also:

"The climate must have been moist and the presence of fossilized wood in the lake beds shows that trees flourished near its shores. While the lake was thus for the most part fresh, periods of aridity alternated with those of comparative humidity, and the lake or portions of it were partially desiccated, permitting the local precipitation of limestone, gypsum, and boron minerals."

Again, in speaking of Furnace creek, he says:⁵

"The Tertiary lake beds consist of white, yellow, and green consolidated clays, friable sandstones with ironstone concretions, rounded and subangular gravels, and thin limestone lenses. Much of the clay shows sun cracks and ripple marks, indicating that the lake was at times shallow and even dry. The subangular form of certain of the gravels indicates that cloudbursts at times spread sheets of detrital deposits over the lake beds. Colemanite and other chemical precipitates interbedded with the other deposits were laid down during periods of unusual evaporation."

Statements of the same kind can be found in all of the publications of the U. S. Geological Survey relating to this territory. On the western slope of the White mountains and Inyo mountains are thick beds of clay containing large numbers of fresh-water mollusks and quite a percentage of phosphates. Mastodon remains have been found in the Owens River valley, and this summer I found similar remains in a clay-bank under the lava cap on the west side of the Panamint valley; also land-snail shells in the surface-soil of a granite hill-side a short distance away.

The geologic history of this territory since the end of the Jurassic period is very different from that of any other part of the United States. During part of the time the Sierra Nevada was covered with an immense glacial sheet. In the passing of this sheet much of the water flowed eastward, as shown by the

⁴ *Bulletin No. 308, U. S. Geological Survey*, pp. 40, 41 (1907).

⁵ *Op. cit.*, p. 198.

moraines in all the cañons on the eastern slope. This was associated with a period of intense volcanic activity, with its attendant elevation and depression of ranges and valleys, making constantly-changing drainage-areas and occasioning a great amount of erosion of recently-formed lavas. That the water area was large and constantly changing is shown by the great extent of the lake-bed deposits and the presence of the remnants of old river-channels now high on the ranges. The remains of the animal and plant life, so far as known, show that the climate was moist and warm, at least at times. These conditions resulted in the accumulation of considerable amounts of boron salts and associated minerals in the water of the lakes. A cutting-off of portions of these lakes by fresh lava-flows or other disturbances, and their resulting desiccation, left the colemanite-deposits at different points in the general stratification of the sedimentary rocks. The presence of numerous small sinks, some with a drainage-area of only a few acres, within the drainage-areas of the large sinks, gives some idea of the geological changes of the past. Mono and Owens lakes, including in their drainage-areas the well-watered eastern slope of the Sierra Nevada, are good-sized bodies of water, kept up by an inflow equal to the evaporation. Still, they have all the characteristics of the marshes of the other sinks. Both contain a considerable percentage of boron salts, and the water of Owens lake is extensively worked for the soda it contains. It is quite probable that until quite recent times there was a general connection from this territory to the open sea by way of the Santa Clara valley, as suggested by Mr. Keyes.

It will be slow and difficult work to get at the relationship of the different strata and exposure of the lake-beds. Constantly-changing conditions during the times in which they were deposited, the great faulting and tilting that they have undergone, the desert country in which they are located, and the roughness of the ranges dividing the existing drainage-areas, all add to the complications. Still, they are of great interest to the prospector as well as to the geologist.

Colemanite may be found in other places than those now known; all the soluble salts of the alkalis are found, and it is quite probable that many of them will be obtained in large

enough quantities of a purity to make them of commercial value. Several small beds of sulphur are known. Gold- and silver-deposits are found in the Tertiary andesites and rhyolites. Some of the old fragments of river-channels have been found to contain placer gold, and I found one place in which the clay of the lake-bed deposits contained an appreciable quantity of gold. Much remains to be done before a true idea of the geological and commercial condition of these Tertiary deposits can be formed.

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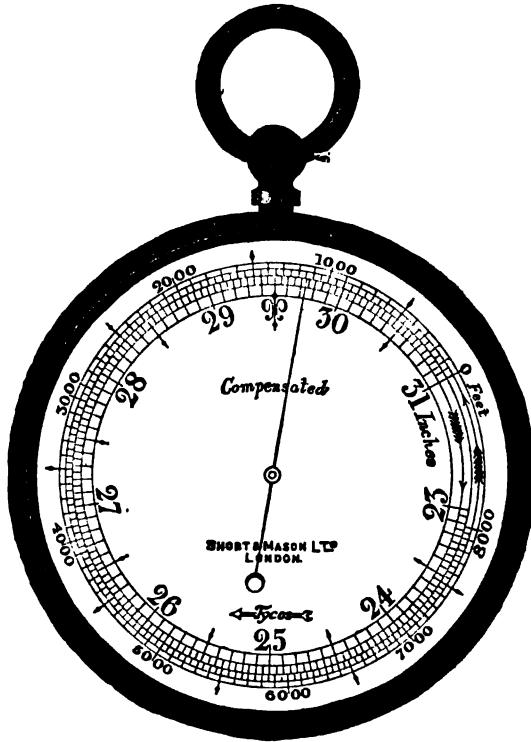
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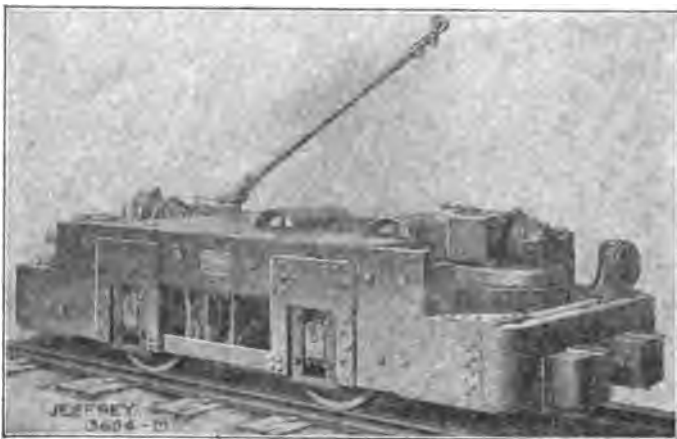
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ERRATA.

Correction to *Bulletin* No. 38, February, 1910:

Page xxv, second line from bottom. For "Johnstown," read "Youngstown."

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This section contains announcements of general interest to the members of the Institute, but not always of sufficient permanent value to warrant republication in the volumes of the *Transactions*.

SECTION II.—TECHNICAL PAPERS AND DISCUSSIONS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

A detailed list of the papers contained in this section is given in the Table of Contents. They have been so printed and arranged (blank pages being left when necessary) that they can be separately removed for classified filing, or other independent use.

A small stock of separate pamphlets, duplicating the technical papers given in Section II. of this Bulletin, is reserved for those who desire extra copies of any single paper.

Comments or criticisms upon all papers given in this section, whether private corrections of typographical or other errors or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.

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R. W. RAYMOND, Secretary ; FRANK LYMAN, Treasurer ;
JOSEPH STRUTHERS, Assistant Secretary and Assistant Treasurer.

DIRECTORS.

JAMES DOUGLAS, JAMES F. KEMP, ALBERT R. LEDOUX.
(Term expires February, 1911.)
THEODORE DWIGHT, CHARLES H. SNOW, R. W. RAYMOND.
(Term expires February, 1912.)
JAMES GAYLEY, CHARLES KIRCHHOFF, FRANK LYMAN.
(Term expires February, 1913.)

Consulting Attorneys, Blair & Rudd, New York, N. Y.

* SECRETARY'S NOTE.—The Council is the professional body, having charge of the election of members, the holding of meetings (except business meetings), and the publication of papers, proceedings, etc. The Board of Directors is the body legally responsible for the business management of the Corporation, and is therefore, for convenience, composed of members residing in New York.

INSTITUTE ANNOUNCEMENTS.

The Pittsburg Meeting.

The Ninety-eighth meeting of the Institute, held at Pittsburg, Pa., March 1 to 5, was thoroughly interesting and profitable professionally, and delightful socially. Though the fogs and floods of an unusually unfavorable season threatened its success, the meeting was blessed with the usual "Institute luck," and both sessions and excursions took place under clear sky and in balmy spring air. A list of 60 papers is given herewith, of which 20 were presented in oral abstract by the authors; and a full report of the proceedings will be published in the *Bulletin* for April. Meanwhile, the following statements are made in advance of that report:

Portrait of Dr. Thomas M. Drown.

A very fine portrait, painted by Mr. Richard B. Farley, Philadelphia, Pa., of Thomas M. Drown, M.D., LL.D. (one of the founders of the Institute in 1871, a Manager in 1872, Secretary from 1873 to 1884, Vice-President in 1892-3, and President in 1897, and, at the time of his death, in 1904, an Honorary Member of the Institute, and President of Lehigh University), was exhibited at the Pittsburg meeting, and attracted much admiration. This portrait has been presented to the Institute by Dr. James Douglas and Mr. James Gayley, and may be seen hereafter in the Engineering Societies Building, 29 West 39th St., New York, N. Y.

The Proposed Excursion to Japan.

It was announced at the meeting that the excursion to Japan, proposed for the autumn of 1910, has been necessarily postponed to some future date.

Papers Presented.

The following papers were presented in oral abstract by the authors :

1. Biographical Notice of Dr. Charles B. Dudley. By R. W. Raymond, New York, N. Y.
2. Biographical Notice of William Metcalf. By H. P. Bope, Pittsburg, Pa.
3. The Development of Hindered-Settling Apparatus. By Robert H. Richards, Boston, Mass.
4. The Pintada Mining Camp, Province of Mendoza, Argentina. By Z. S. Beyl, Buenos Aires, So. Am.
5. Systematic Exploitation in the Pittsburg Coal-Seam. By F. Z. Schellenberg, Pittsburg, Pa. Discussed by Frank W. De Wolf, Urbana, Ill.
- *6. A Commercial Fuel-Briquette Plant. By William H. Blauvelt, Syracuse, N. Y. (March *Bulletin*.) Discussed by C. W. Malcolmson, Chicago, Ill.; E. W. Parker, Washington, D. C.; and John Birkinbine, Philadelphia, Pa.
- *7. Dust-Explosions in Coal-Mines. By George S. Rice, Pittsburg, Pa. (March *Bulletin*.)
8. The Gaseous Decomposition-Products of Black Powder. By C. M. Young, Lawrence, Kan.
9. Work of the Technologic Branch at Pittsburg. By J. A. Holmes, Washington, D. C.
10. Accumulation of Petroleum in the Earth. By David T. Day, Washington, D. C.
11. The School of Mines at the University of Pittsburg. By M. E. Wadsworth, Pittsburg, Pa.
12. The Technical Schools of the Carnegie Institution. By Fred. Crabtree, Pittsburg, Pa.
13. New Method of Cyaniding Gold- and Silver-Ores. By E. Gybbon Spilsbury, New York, N. Y.
14. The Dwight and Lloyd Sintering-Process. By A. S. Dwight, New York, N. Y.
15. The Huronian as a Gold-Bearing Terrane. By Robert Bell, Ottawa, Can.
16. The Action of Explosives on Rocks of Different Degrees of Hardness. By Walter O. Snelling, Pittsburg, Pa.

17. Introduction of the Basic Steel-Process in the United States. By George W. Maynard, New York, N. Y.
 18. Electric Mine-Hoists. By Karl A. Pauly, Schenectady, N. Y.
 19. Field Investigations of Structural Materials for Use in Federal Buildings. By E. F. Burchard, Washington, D. C.
 20. Coal and Iron-Ore in Western Oaxaca, Mexico. By J. L. W. Birkinbine, Mexico City, Mex.
 21. The Chemical Control of Slimes. By Harrison Everett Ashley, Pittsburg, Pa.
- The following papers were presented by title for publication in the *Bulletin* of the Institute. Those marked with an asterisk (*) were distributed in printed form.
- *22. A Method of Calculating Sinking-Funds, and a Table of Values for Ordinary Periods and Rates of Interest. By John B. Dilworth, Philadelphia, Pa. (November *Bulletin*.)
 - *23. Cyanide-Plant and Practice at the Minas del Tajo, Rosario, Sinaloa, Mexico. By George A. Tweedy and Roger L. Beals, Rosario, Sinaloa, Mexico. (February *Bulletin*.)
 24. The Copper-Provinces of the United States. By William H. Emmons, Chicago, Ill.
 - *25. The Behavior of Copper-Slags in the Electric Furnace. By Lewis T. Wright, San Francisco, Cal. (March *Bulletin*.)
 - *26. Chemical Laboratories in Iron- and Steel-Works. By George W. Maynard, New York, N. Y. (November *Bulletin*.)
 27. Notes on Field-Methods of Assaying, *i.e.*, an Assay-Shop in an Ordinary Valise. By S. K. Bradford, National, Nev.
 - *28. The Girod Electric Furnace, and the French Works Using the Paul Girod Steel-Process. By Wilhelm Borchers, Aachen, Germany. (January *Bulletin*.)
 29. Electricity in Mines. By William Kelly, Vulcan, Mich.
 - *30. A New Separator for the Removal of Slate from Coal. By W. S. Ayres, Hazleton, Pa. (December *Bulletin*.)
 31. Improvements in Blast-Roasting. By Herbert Haas, San Francisco, Cal.

32. Ultimate Source of Ores. By Charles R. Keyes, Des Moines, Iowa.
- *33. The Genesis of the Leadville Ore-Deposits. By Max Boehmer, Denver, Colo. (February *Bulletin*.)
34. Heats of Formation of Some Ferro-Calcic Singulo-Silicates. By H. O. Hofman and C. Y. Wen, Boston, Mass.
- *35. Professional Ethics. By R. W. Raymond, New York, N. Y. (January *Bulletin*.)
- *36. Application of Descriptive Geometry to Mining-Problems. By Joseph W. Roe, New Haven, Conn. (March *Bulletin*.)
- *37. The Behavior of Copper-Mattes and Copper-Nickel Mattes in the Bessemer Converter. By D. H. Browne, Copper Cliff, Ontario, Can.
38. Deacidifying Furnace-Gases. By F. T. Havard, Madison, Wis.
39. Discussion of the paper of Audley H. Stow, Pressure-Fans *vs.* Exhaust-Fans. By R. V. Norris, Wilkes-Barre, Pa.
- *40. Discussion of the paper of Lewis T. Wright, Metal-Losses in Copper-Slags. By J. Parke Channing, New York, N. Y.
- *41. Discussion of the paper of Charles R. Keyes, Borax-Deposits of the United States. By A. M. Strong, Bishop, Cal. (February *Bulletin*.)
- *42. Discussion of the paper of E. W. Parker, The Conservation of Coal in the United States. By William L. Saunders, New York, N. Y. (December *Bulletin*.)
43. Reply to Mr. Buckley's Discussion of paper, Ozark Lead- and Zinc-Deposits. By Charles R. Keyes, Des Moines, Iowa.
44. Reply to Discussion by Messrs. Courtis and Macdonald of paper, Genesis of the Lake Valley, New Mexico, Silver-Deposits. By Charles R. Keyes, Des Moines, Iowa.
45. Discussion of the paper of James Douglas, Conservation of Natural Resources. By James Douglas, New York, N. Y.

46. Discussion of the paper of Albert F. J. Bordeaux, The Cyaniding of Silver-Ores in Mexico. By Herbert A. Megraw, San Luis de la Paz, Guanajuato, Mex.
- *47. Discussion of the paper of H. O. Hofman and C. R. Hayward, Pan-Amalgamation: an Instructive Laboratory-Experiment. By George W. Riter, Salt Lake City, Utah. (March *Bulletin*.)
- *48. Mining-Conditions in the Belgian Congo. By Sydney H. Ball, New York, N. Y., and Millard K. Shaler, Lawrence, Kan.
- *49. The Combustion-Temperature of Carbon and Its Relation to Blast-Furnace Operation. By Clarence P. Linville, State College, Pa. (March *Bulletin*.)
- *50. The Fushun Colliery, South Manchuria. By Warden A. Moller, Tientsin, China.
51. Federal Coal-Mines in the Philippines. By Oscar H. Reinholt, Pasadena, Cal.
52. The Chemical Control of Slimes. By Harrison Everett Ashley, Pittsburg, Pa.
53. Theoretical Consideration of Combustion in Burning Cement. By Byron E. Eldred, Tuckahoe, N. Y.
54. Discussion of the paper of Edmund D. North, Glass Mine-Models. By A. Scott Reid, London, England.
- *55. Professional Ethics. By Victor G. Hills, Denver, Colo. (March *Bulletin*.)
- *56. Sampling Anode-Copper, with Special Reference to Silver-Content. By William Wraith, Anaconda, Mont. (March *Bulletin*.)
57. The Giroux Shaft. By Everard Arnold, Kimberly, Nev.
58. The Form of Coal-Analysis Best Adapted for Comparative Purposes. By M. R. Campbell, Washington, D. C.
59. Discussion of the paper of Edmund D. North, Glass Mine-Models. By A. Scott Reid, London, England.
60. Some Experimental Work on Mining-Education. By M. E. Wadsworth, Pittsburg, Pa.

Founder Societies Dinner.

On Thursday evening, Feb. 17, 1910, the present governing boards and past-Presidents of the United Engineering Society, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, and the American Institute of Electrical Engineers dined together at the Engineers' Club, for the purpose of extending acquaintanceship, and informally discussing future plans for the general welfare. Thirty-four representatives attended. Henry G. Stott, the newly-elected President of the Trustees of the United Engineering Society, officiated as chairman, and introduced John W. Lieb, Jr., Treasurer of the United Engineering Society, who gave an abstract of his recent annual report and called attention to the fact that practically all of the available office-space in the Engineering Societies Building has now been allotted to various associate societies. Among the speakers who followed were: Messrs. F. J. Miller, R. W. Raymond, Calvert Townley, Albert R. Ledoux, F. R. Hutton, C. F. Scott, S. S. Wheeler, and T. C. Martin. General satisfaction was expressed with the successful administration of the affairs of the United Engineering Society during the three years' experience in the occupation of the building.

New Board of Trustees, United Engineering Society.

In accordance with the By-Laws of the United Engineering Society, three members of its Board of Trustees were retired at the annual meeting of the Board held on Jan. 27, 1910, after completion of their three-year term. Theodore Dwight was the retiring member representing the American Institute of Mining Engineers, and he was succeeded by Joseph Struthers, who had been elected to fill the vacancy at the meeting of the Institute Board of Directors held on Jan. 14, 1910. The three representatives of the Institute on the Board of Trustees now are: E. E. Olcott, Charles Kirchhoff, and Joseph Struthers. H. G. Stott was unanimously elected President of the Board.

At the meeting held on February 24, Joseph Struthers was elected Treasurer.

Proceedings of the Board of Directors.

The following acts of the Directors are reported for the information of members :

At a meeting held Nov. 11, 1909, after unanimous recommendation by the Council, M. Alexandre Pourcel was unanimously elected an honorary member of the Institute in recognition of his distinguished researches in the science and contributions to the practice of the metallurgy of iron and steel.

The Secretary reported that books, etc., were from time to time received as gifts by the United Engineering Society, and therefore could not be properly treated as belonging to the library of either of the three Founder Societies, although the said societies were, in some sense, owners thereof through their connection with the United Engineering Society. Also, that the Library Conference Committee, consisting of one representative from the Library Committee of each of the three societies, desired, from time to time, the purchase of reference-books, such as directories, dictionaries, etc., or of library equipment for the joint use of the societies, and that articles so purchased could not properly be carried on the inventory of the library of either society.

It was voted : (1) That gifts of books, etc., received by the United Engineering Society, shall be regarded as the property of that society; and the Library Committee of the Institute is hereby discharged, concerning such books, etc., from the responsibility imposed by By-Law X.

(2) That the Secretary is hereby authorized to consent to the purchase, for joint use of the Founder Societies, of such books or library equipment as may be approved by the unanimous vote of the Library Conference Committee, and to pay from the funds of the Institute its proportion of one-third the cost thereof. *Provided*, That said payments, together with the purchases of books, etc., for the library of the Institute, shall not exceed the amounts appropriated by this Board for library purchases and bindings.

At a meeting held Jan. 10, 1910, Mr. Theodore Dwight, Treasurer of the Land Fund Committee, presented a report of the work done by this committee during the year 1909, which shows a total of subscriptions collected during the year of

\$22,589.75, and promised subscriptions of \$17,600. Payments were made by this committee on the land mortgage during the year amounting to \$22,000, which, together with the \$15,000 paid by the Institute, reduces the debt of the land fund from \$125,000, Jan. 1, 1909, to \$88,000, Jan. 1, 1910. The deferred payments, amounting to \$17,600, together with the present balance on hand of \$1,139.75, totaling \$18,739.75, will further reduce the balance due on the land mortgage to \$69,260.25.

Dr. Joseph Struthers was unanimously elected a trustee of the United Engineering Society, to serve for a term of three years, succeeding Mr. Theodore Dwight, whose term expired January, 1910.

At a meeting held February 15, 1910, the following officers were elected: *President*, James Gayley; *Vice-President*, James Douglas; *Secretary*, R. W. Raymond; *Treasurer*, Frank Lyman.

The following standing committees were appointed to serve during the ensuing year:

Finance Committee: James Douglas, Theodore Dwight, and Albert R. Ledoux.

Library Committee: James F. Kemp, Charles H. Snow, and R. W. Raymond.

Financial Statement.

The following statement of receipts and expenditures from Jan. 1 to Dec. 31, 1909, is published by authority of the Board of Directors:

RECEIPTS.	
Balance from statement of January, 1909,	\$3,888.58
Annual dues,*	\$37,909.18
Life memberships,	890.00
Initiation fees,	1,990.00
Binding of <i>Transactions</i> ,	3,668.30
Sale of publications, electrotypes, advertising, and miscellaneous receipts,	9,768.77
	54,226.25
Interest on bonds and deposits,	184.66
Sale of 6 \$1,000 N. Y. Central & Hudson River R.R. Lake Shore Collateral 3½ per cent. Coupon Bonds (net),	5,140.83
Sale of 13 \$1,000 Pennsylvania R.R. Co. 6 per cent. Registered Bonds (net),	13,567.93
	18,708.76
	\$77,008.25

* \$18,875 of this amount has been applied to subscriptions to the *Bulletin* in accordance with post-office regulations.

DISBURSEMENTS.

Printing Vol. XXXIX. of the <i>Transactions, Bulletin</i> , extra pamphlets, and advertising expenses, etc.,	\$12,355.34	
Printing circulars and ballots,	231.10	
Binding Vol. XXXIX. of the <i>Transactions</i> ,	3,458.00	
Binding miscellaneous volumes,	465.55	
Engraving and electrotyping,	567.51	
Secretary's department, including clerks, stenographers, and expenses of editing and proof-reading, and special assistance in connection with meetings,	11,428.60	
Treasurer's department, including collection of dues, shipping, etc.,	6,087.50	
Librarian and assistants,	1,854.80	
Postage,	3,711.33	
Stationery,	554.31	
Express and freight charges,	1,792.10	
Telephone,	207.90	
Telegrams, cables, carfares, etc.,	57.96	
Office supplies and repairs,	76.04	
Refunding miscellaneous payments,	138.22	
Insurance premiums (Surety),	95.00	
Collection charges,	37.16	
Extra clerical assistance,	76.66	
Special stenographers and expenses of meetings,	1,722.55	
Auditing,	125.00	
Office cleaning and sundry expenses,	32.55	
		\$45,075.18
Principal on account, Land Mortgage,	\$15,000.00	
Interest at 4 per cent., for 1909, on unpaid balance of land mortgage on 25 to 33 West 39th St. (\$125,000, January 1, 1909, reduced to \$88,000 January 1, 1910),	4,276.66	
Quota of current expenses of building 25 to 33 West 39th St.,	6,000.00	
		\$25,276.66
Special editing, part payments on printing and binding special edition, new volume of <i>Genesis of Ore-Deposits</i> ,	39.00	
Library equipment,	173.33	
Library additions of books, periodicals, etc., binding of exchanges, and stationery (expenditure from appropriation of \$1,000),	827.04	
Furniture and fixtures,	68.45	
Balance,	5,548.59	
		\$77,008.25

NEW YORK, N. Y., February 7, 1910.

We have examined the above statement, compared it with the books and vouchers and find same correct.

(Signed) BARROW, WADE, GUTHRIE & Co.,
Certified Public Accountants.

Proceedings of the Council.

The following report is published for the information of members :

Institute Meetings.

There were two meetings of the Institute held during the year 1909 for the reading and discussion of papers—the Ninety-sixth Meeting, in New Haven, February 23 to 25, and the Ninety-seventh Meeting, in Spokane, September 28 to 29.

A detailed record of the proceedings of these meetings, including a description of the entertainments and excursions connected therewith, has been published and duly distributed to the members: the New Haven meeting in *Bulletin* No. 28, April, 1909, pp. 425 to 437, and the Spokane meeting in *Bulletin* No. 36, December, 1909, pp. 1059 to 1118. At the New Haven meeting there were presented 27 papers and 5 discussions, oral and written; in these discussions 18 separate contributors participated. At the Spokane meeting there were presented 27 papers and 8 discussions, oral or written; in these discussions 14 contributors participated. At the New Haven meeting the names of 145 members and guests were registered at the Institute headquarters; this number, however, does not represent all who were present at the sessions and the excursions to Ansonia and Bridgeport. In connection with the Spokane meeting, the number of members and guests registered was approximately 200, but the total number participating in the trip through the Yellowstone Park and the excursions to Butte, Anaconda, and the Cœur d'Alene district, or attending, in whole or in part, the sessions at Spokane, and the subsequent excursions to Seattle, Tacoma, Portland and the Dalles of the Columbia, Salt Lake City, Bingham Cañon, Glenwood Springs, and through the Royal Gorge to Pueblo and Colorado Springs, exceeded 400.

Publications.

Transactions.—Volume XXXIX. of the *Transactions*, an octavo of 1,006 pages, comprising 50 papers and 16 discussions presented during the year 1908, was issued and distributed to members in June, a few weeks earlier in the year than the corresponding appearance of Volume XXXVIII. With the excep-

tion of the index, now being compiled, the material for Volume XL., forming in all about 1,000 pages, is in the hands of the printer, and it is expected that the bound volume will be off the press and ready for distribution in June, 1910.

Bulletin.—Twelve numbers of the *Bulletin* (Nos. 25 to 36), containing the technical papers and discussions of the Institute (in "subject to revision" form) and announcements of general interest to the members of the Institute, such as Library accessions and requirements during the year 1909; notices of meetings of the Institute and of other societies; lists of proposed members and associates; changes of address; deaths of members; obituary notices; Index of Subjects and Authors, etc., have been published and distributed promptly throughout the year 1909. The number of pages occupied by technical papers and discussions amounts to 1,210, to which are to be added 326 pages of announcements, and 184 pages of advertising matter, making a total of 1,720 pages of printed matter.

The editorial and business management of the *Bulletin*, Volume XXXIX. and the forthcoming Volume XL. of the *Transactions* continues in charge of Dr. Joseph Struthers, Assistant Secretary and Editor of the Institute.

Membership.

Changes in membership have taken place during the year as follows: 1 honorary member, 1 honorary associate, 190 members and 11 associates have been elected; 6 members have been reinstated, 4 members re-elected, 2 members have become honorary members, and 6 associates have become members; the deaths of 32 members and 1 associate have been reported; 60 members and 4 associates have resigned; and 67 members and 6 associates have been dropped from the roll by reason of non-payment of dues, loss of correct address, etc.* These changes are shown in the accompanying table.

The total membership on Jan. 1, 1910, was 4,284, as compared with 4,241 on Jan. 1, 1909—a net gain for the year of 43 members.

* Many of these, no doubt, will be reinstated, as has been the case in former years.

*Membership of the American Institute of Mining Engineers,
Jan. 1, 1910.*

	Honorary Members.	Honorary Associates.	Members.	Associates.	Totals.
Membership Dec. 31, 1908.....	11	.....	4,066	164	4,241
Gains: By Election.....	1	1	190	11	203
Change of Status.....	2	.....	6	.....	8
Reinstatement.....	.....	.....	6	.....	6
Re-election.....	.....	.....	4	.....	4
Losses: By Resignation.....	.....	.....	60	4	64
Change of Status.....	.....	.....	2	6	8
Dropping.....	.....	.....	67	6	73
Death.....	.....	.....	32	1	33
Total gains.....	3	1	206	11	221
Total losses.....	.....	.....	161	17	178
Membership Dec. 31, 1909.....	14	1	4,111	158	4,284

The list of deaths reported during the year 1909 comprises the following names, the figures in parentheses indicating the year in which the persons named were elected to membership:

Members and Associates.—William Adams (1905), Robert S. Brooks (1906), James W. Brown (1905), Raymond B. Brown (1895), F. G. Bulkley (1882), Dr. Charles B. Dudley (1878), Richard Eames, Jr. (1888), George G. Francis (1880), Persifor Frazer (1871), Edward L. Fuller (1904), John M. Grice (1908), Rasmus Hanson (1896), Harold H. Harvey (1903), Alphonse Hennin (1888), H. August Hunicke (1883), Algernon K. Johnston (1899), Jerome Keeley (1876), Emil Krabler (1891), L. G. Laureau (1878), Frank A. Lucy (1903), John E. McCurdy (1897), Charles C. Mattes (1881), William Metcalf (1875), Stephen C. Miller (1904), Israel W. Morris (1875), John W. Nesmith (1896), Bertel Peterson (1900), Robert Pitcairn (1881), Jasper R. Rand (1900), Davis Richardson (1905), William H. Singer (1873), James Stirling (1906), Delos V. A. Williams (1903), T. F. Witherbee (1871).

Proceedings of the Annual Meeting.

At the Annual Business Meeting of the Institute, held Feb. 15, 1910, the following officers were elected:

COUNCIL.

President of the Council.
(To serve for one year.)

D. W. BRUNTON, Denver, Colo.

Vice-Presidents of the Council.

(To serve for two years.)

BENJAMIN B. LAWRENCE,	.	.	.	.	.	New York, N. Y.
JOSEPH W. RICHARDS,	.	.	.	.	.	South Bethlehem, Pa.
ALBERT SAUVEUR,	.	.	.	.	.	Cambridge, Mass.

Secretary of the Council.

(To serve for one year.)

R. W. RAYMOND,	.	.	.	.	.	New York, N. Y.
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Councilors.

(To serve for three years.)

ROBERT E. JENNINGS,	.	.	.	.	.	New York, N. Y.
WILLIAM KELLY,	.	.	.	.	.	Vulcan, Mich.
CHARLES F. RAND,	.	.	.	.	.	New York, N. Y.

DIRECTORS.

(To serve for three years.)

JAMES GAYLEY,	.	.	.	.	.	New York, N. Y.
CHARLES KIRCHHOFF,	.	.	.	.	.	New York, N. Y.
FRANK LYMAN,	.	.	.	.	.	New York, N. Y.

[SECRETARY'S NOTE.—The complete list of all officers of the Institute will be found on p. iv. of this number of the *Bulletin*. The following explanation, first published in *Bi-Monthly Bulletin*, No. 8, March, 1906, p. viii., is here repeated in order to recall to old members, and convey to new ones, the relations of the two governing bodies as determined by the Certificate of Incorporation of the Institute, and the Constitution and By-Laws adopted in accordance therewith.

The body legally responsible for the business management is the Board of nine Directors (three elected annually to serve three years), which elects its own officers. This body, for reasons of practical convenience, is composed of well-known members residing in New York City, and able to attend, without serious inconvenience or expense, the necessary meetings of the Board. The officers of this Board are legally the officers of the Institute. But, apart from business management, the Board exercises no control over the election of members, or the professional and technical work of the Institute, except that its vote is required to elect honorary members, upon the recommendation of the Council.

The Council is a body constituted in all respects (except that it has no Treasurer) like the Council existing before the incorporation of the Institute, in January, 1905, and charged with all duties and powers, except those which the Board of Directors must legally perform. It elects members, appoints the times and places of professional meetings, and controls the publication and distribution of papers and volumes, etc. Its members (President, Vice-Presidents and Councilors) are elected by the members of the Institute, voting in person or by proxy, and after publication of the nominations received; and it is intended to represent, as far as practicable, both the professional and the geographical distribution of the membership. Consequently, whatever professional honor attaches to official position belongs to membership in the Council, rather than in the legal Board of Directors. This remark implies no disparagement of the members of the latter body, every one of whom has served, or is now serving, as a member of the Council. But it is only fair to explain that their election and continued reelection as Directors is simply a matter of legal convenience.]

Proposed Amendments to the Constitution.

The consideration of the proposed amendment to Article III. of the Constitution, whereby, in the first line of said article, the word "fifteen" should be substituted for the word "ten," was postponed to an adjourned session of the present annual meeting, to be held at a time fixed by the Board of Directors upon due notice given as provided by Article IV., Section 2, of the Constitution for the calling of special business meetings,

Provided that, if the Board of Directors shall not call such adjourned session, then the consideration of this proposed amendment shall be in order at the annual meeting of February, 1911, and

Provided also that, for the purpose of the said consideration of this amendment, or any proposed amendment thereof, new proxies shall be sent to all members and associates entitled to vote, which shall be so drawn as to cover the questions thus concerned, and permit an intelligent vote thereon.

Annual Report of Librarian.*(Abstract.)*

Books and pamphlets in the Library during the period July 1, 1908, to Dec. 31, 1909, are listed in the accompanying table. During this time 1,531 volumes, chiefly periodicals, have been bound at a cost of \$1,339.92.

Books and Pamphlets in the Library.

	Accessions.		Total in Library.	
	Books.	Pamphlets.	Books.	Pamphlets.
A. S. M. E.....	562	67	8,607	1,406
A. I. M. E.....	1,176	2,638	18,119	4,542
A. I. E. E.....	1,573	1,152	13,936	1,248
United Engineering Society.....	37	23	37	23
Total.....	3,348	3,880	40,699	7,219

Periodicals.

On July 1, 1908, there were 690 current periodicals in the joint libraries, 259 being duplicates, and on Dec. 31, 1909, the number of periodicals regularly received, exclusive of duplicates, was 557.

Seventy-four of the duplicate sets were sold during 1909 at a net profit of \$150.21. In addition, \$111.16 was received from the sale of various books and odd periodicals.

Researches and transcriptions have been made during the period to the amount of \$31.

Circulation of Books.

Call cards were placed in commission on Mar. 1, 1909, and the following table indicates the character of the books and periodicals consulted. This tabulation, however, represents only about a third of the circulation, as many people go directly to the shelves and do not ask for information.

Architecture,	6	Hydraulic Engineering,	17
Bibliography,	2	Mathematics,	16
Biography,	6	Marine Engineering,	10
Chemical Technology,	25	Mechanical Engineering,	102
Chemistry,	14	Metallurgy,	65
Civil Engineering,	19	Mining Engineering,	52
Description and Travel,	6	Miscellaneous,	7
Electrical Engineering,	75	Periodicals,	111
Electricity,	33	Physics,	21
Engineering,	31	Railroad Engineering,	16
General Geology,	83	Railroad Engineering, Electric,	17
		Total,	734

The attendance in the Library is shown in the following table:

Library Attendance.

January, 1908—December, 1909.

1908.	Day.	Night.	1909.	Day.	Night.
January.....	541	148	January.....	485	250
February.....	439	241	February.....	533	254
March.....	417	203	March.....	536	280
April.....	403	210	April.....	529	217
May.....	400	196	May.....	462	221
June.....	419	136	June.....	484	196
July.....	441	.....	July.....	472	.....
August.....	362	.....	August.....	472	.....
September.....	392	125	September.....	434	220
October.....	381	180	October.....	471	238
November.....	435	200	November.....	479	223
December.....	520	441	December.....	545	301
Total.....	5,151	2,080	Total.....	5,901	2,402

Total for 1908 : 7,231.

Total for 1909 : 8,303.

During 1909 the general reference section of the Library of the Engineering Societies has been strengthened by the addition of the following reference books :

Bartholomew's New Atlas of the World's Commerce.
Bouvier's Law Dictionary, 2 vols.
Calisch's Dictionary of the Dutch Language, 2 vols.
Cyclopedia of Building Trades, 6 vols.
Dietrich's Bibliographie der deutschen Zeitschriften Literatur.
Flügel's Universal German-English Dictionary, 3 vols.
Larousse's Dictionnaire Française, 22 vols.
Meyer's Grosses Konversation Lexikon, 20 vols.
Mullhouse's Italian Dictionary, 2 vols.
Rand & McNally Business Atlas.
Michaelis's Portuguese-English Dictionary, 2 vols.
Webster's New International Dictionary.
Qui Etes-Vous?
New York Business Directory.
Wer Ist's?

This department is also equipped with :

The Annual Library Index, 1908 (popular engineering material arranged in classes).

The Engineering Index, which is arranged separately in binders by the following classes: civil engineering; electrical engineering; industrial economy; marine and naval engineering; mining and metallurgy; mechanical engineering; railway engineering; street and electric railways.

Engineering Digest.

Le Mois Scientifique et Industriel.

Technical Index.

Reader's Guide.

Poole's Index.

Technical Press Index.

Repertorium der technischen Journal Literatur, superseded in 1908 by

Technische Auskunft, published by Bibliographical Institute of Berlin.

Stone & Webster's Current Literature.

There is also a card index of the literature in the engineering periodicals received by the Library of the Engineering Societies. Many of these entries duplicate those of the engineering index, but the library data are available several weeks earlier than the monthly printed index.

The two front alcoves have been arranged to be of practical use to the general public. They possess more advantages than are usually permitted in any of the large public libraries.

To the present equipment will be added very soon :

a Indexes of periodicals and transactions of societies.

- b* All current foreign, scientific and technical periodicals.
- c* Official patent publications of all countries.
- d* Lists of periodicals in other libraries.
- e* The undertaking of researches and translations at hourly rates.
- f* A bulletin board for new books, and coming meetings and congresses.

Meetings of Other Societies.

American Institute of Electrical Engineers.—The two hundred and forty-fifth meeting of the American Institute of Electrical Engineers will be held in the auditorium of the Engineering Societies Building, No. 33 West Thirty-ninth Street, New York, N. Y., on Friday evening, April 8, 1910. The meeting is to be held under the auspices of the Educational Committee. Dr. Samuel Sheldon, Professor of Physics and Electrical Engineering, Brooklyn Polytechnic Institute, will present a paper entitled, Education for Leadership in Electrical Engineering. The paper will appear in the April *Proceedings of the American Institute of Electrical Engineers*.

International Congress for Mining, Metallurgy, Applied Mechanics, and Practical Geology, Düsseldorf, 1910.

As already announced in previous *Bulletins*, this Congress will meet at Düsseldorf during the last week in June, 1910. Extensive preparations are in progress, including visits to technical institutions and industrial establishments, excursions to localities of geologic interest, etc., which will have a direct bearing on the papers and addresses presented at the meeting.

Full information concerning membership, meetings and excursions, classification of subjects, etc., is given in *Bulletin No. 37*, January, 1910.

Applications for membership in this Congress should be made not later than Mar. 1, 1910. Inquiries concerning announcement of proposed papers, length and time of presentation, suggestions, etc., may be addressed to Dr. E. Schrödter, Secretary of the Committee of the Congress, Düsseldorf, Jacobistrasse 3/5, Prussia.

How to Use the "Transactions" of the Institute.

Buy a copy of the Complete Analytical and Alphabetical Index of Volumes I. to XXXV., inclusive.

If you own a full set of the *Transactions*, this Index will make the whole of it instantaneously available without detailed research into each volume separately.

If you do not own such a set, this Index will be even more valuable, for it will show you what particular papers you need to know more about, and perhaps to study. Thus, any person possessing this Index can ascertain at once what has been published in the *Transactions* on a given question, and can learn, by writing to the Secretary, what is its nature, whether it is still to be had in pamphlet form, where it can be consulted in a public library, at what cost it can be copied by hand, etc., etc.

In short, to those who own complete sets of the *Transactions*, this Index will be a great convenience; but to those who do not, it will be a professional necessity.

This volume is an octavo of 706 pages, containing more than 60,000 entries, duly classified with sub-headings, and including abundant cross-references. It has not been stereotyped, and the edition is limited to 1,600 copies. The price of the volume, bound in cloth, is \$5, and bound in half-morocco to match the *Transactions*, \$6. The delivery charges will be paid by the Institute on receipt of the above price.

Hydrographic Chart.

Owing to the great value to hydrographers of the chart contained in the paper, A Graphic Solution of Kutter's Formula, by L. I. Hewes and Joseph W. Roe (*Bulletin No. 29*, May, 1909, p. 454), a special edition for office or field use has been printed on durable cloth. Copies of this separate chart may be obtained, at a cost of 50 cents each, on application to the office of the Secretary of the Institute.

Special Notice.

Attention is respectfully requested to the announcement on pages 14 and 15 of the advertising section of this *Bulletin* concerning certain books and periodicals needed to complete sets in the Library.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

AMERICAN INSTITUTE OF MINING ENGINEERS.

UNITED ENGINEERING SOCIETY.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays, from September 1 to June 30, and from 9 A.M. to 6 P.M. during July and August.

RULES.

For the protection and convenience of members, the following rules have been adopted:

The Secretary of each Society will, upon application, issue to any member of his Society in good standing a personal, non-transferable card, entitling him to the use of the Libraries in the alcoves of the Reading-Room. This card must be signed by the person receiving it, and surrendered at the desk at the time of its presentation. At every visit he must identify himself by signing his name in the registry.

The first two alcoves are free to all; and admission to the inside alcoves is given only upon proper introduction.

The above rules apply to all persons except officers of the three Societies, personally known as such to the librarians.

The librarians are not permitted to lend to any person any catalogued pamphlet or volume, unless authorized in writing so to do by the Secretary or Chairman of the Library Committee of the Society to which the pamphlet or volume belongs.

Any person discovering a mutilation or defect in any book of the libraries is requested to report it to the librarian on duty.

Library Accessions.

Feb. 1 to Mar. 1, 1910.

[Copies of the list of additions to the Libraries of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers can be obtained on application to the Secretary of the American Institute of Mining Engineers.]

AMERICAN ELECTROCHEMICAL SOCIETY. Transactions. Vol. 16. South Bethlehem, 1909. (Exchange.)

AMERICAN IRON AND STEEL ASSOCIATION. Directory of the Iron and Steel Works of the United States, 1884, 1892, 1894, 1896, and Supplement to 1903. Philadelphia, 1884, 1892, 1894, 1896, 1903. (Gift of James M. Swank.)

AMERICAN MINING CONGRESS. Monthly Bulletin. Vol. 13, Nos. 1-2. Denver, 1910. (Exchange.)

——— Proceedings. Vol. XII. Denver, 1909. (Exchange.)

AMERICAN SOCIETY FOR TESTING MATERIALS. Proceedings. Vol. IX., 1909. Philadelphia, 1909. (Exchange.)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Year Book, 1910. New York, 1910. (Exchange.)

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS. Proceedings. Dec., 1909. Chattanooga, 1909. (Gift.)

AUSTRALASIAN INSTITUTE OF MINING ENGINEERS. Transactions. Vol. 13. Melbourne, 1909. (Exchange.)

CATALOGUE OF CANADIAN BIRDS. By J. Macoun and J. M. Macoun. Ottawa, 1909. (Exchange.)

CATASTROPHES MINÈRES AMÉRICAINES. By M. J. Taffanel and M. P. Dunaimé. (Extrait Annales des Mines, July-Aug., 1909.) Paris, H. Dunod et E. Pinat 1909. (Gift of Publishers.)

CENTURY ASSOCIATION. Reports, Constitution, By-Laws, and List of Members, 1908. New York, 1909. (Gift.)

CLARKSON BULLETIN. Vol. 7, No. 1, Jan., 1910. Potadam, 1910. (Exchange.)

CLEVELAND ENGINEERING SOCIETY. Journal. Vol. 2, No. 2. Cleveland, 1909. (Gift of Society.)

DE BEERS CONSOLIDATED MINES, LTD. Annual Report, 21st. Kimberley, 1909. (Gift of A. F. Williams.)

DISTRIBUTION OF THE MAGNETIC DECLINATION IN ALASKA AND ADJACENT REGIONS FOR 1910. By R. L. Faris. (U. S. Coast and Geodetic Survey. Appendix No. 4—Report, 1909.) Washington, 1910. (Exchange.)

ENGINEERS' CLUB. Constitution, Rules, Officers, and Members, 1909. New York, 1909. (Gift.)

FIRE TAX AND WASTE OF STRUCTURAL MATERIALS IN THE UNITED STATES. (Bulletin No. 418, U. S. Geological Survey.) By H. M. Woslin and J. L. Cochrane. Washington, 1910. (Exchange.)

FLUORSPAR DEPOSITS OF KENTUCKY. (Bulletin No. 9, Kentucky Geological Survey.) Lexington, 1907. (Gift of Dr. R. W. Raymond.)

GENERAL INDEX TO THE FOUR VOLUMES OF ORE DRESSING. By R. H. Richards. New York, McGraw-Hill Book Co., 1909. (Gift of Publishers.)

INFLUENCE OF FORESTS ON CLIMATE AND ON FLOODS. Report on. By W. L. Moore. Washington, 1910. (Gift.)

INNOKO GOLD-PLACER DISTRICT, ALASKA. (Bulletin No. 410, U. S. Geological Survey.) By A. G. Maddren. Washington, 1910. (Exchange.)

- INTERNATIONAL RAILWAY FUEL ASSOCIATION. Proceedings of Annual Convention, 1st, 1909. Chicago, 1909. (Gift of International Railway Association.)
- IRON AND STEEL INSTITUTE. Journal. No. II., 1909. London, 1909. (Exchange.)
- IRON-ORE RESOURCES OF THE WORLD. By E. A. Shubert. (Bulletin No. 21, Appalachian Engineering Association.) N. p., n. d. (Gift.)
- IRON-ORES, FUELS, AND FLUXES OF THE BIRMINGHAM DISTRICT, ALABAMA. (Bulletin No. 400, U. S. Geological Survey.) By E. F. Burchard and Charles Butts. Washington, 1910. (Exchange.)
- IRON TRADE REVIEW. Vols. 28, 30. Cleveland, 1895, 1897. (Exchange.)
- JUNIOR INSTITUTION OF ENGINEERS. Journal and Record of Transactions. Vol. 19. London, 1909. (Exchange.)
- LAKE SUPERIOR MINING INSTITUTE. Proceedings. Vol. 14. Ishpeming, 1909. (Exchange.)
- LIVERPOOL ENGINEERING SOCIETY. Transactions. Vol. 30. Liverpool, 1909. (Exchange.)
- MINERAL PRODUCTION OF CALIFORNIA FOR 22 YEARS, 1887-1908. (Sheet.) (Bulletin No. 55, California State Mining Bureau.) San Francisco, n. d. (Exchange.)
- MINERAL PRODUCTION OF CALIFORNIA, BY COUNTIES, 1908. (Sheet.) (Bulletin No. 54, California State Mining Bureau.) San Francisco, n. d. (Exchange.)
- MINERAL PRODUCTIONS, COUNTY MAPS, AND MINING LAWS OF CALIFORNIA. (Bulletin No. 56, California State Mining Bureau.) San Francisco, n. d. (Exchange.)
- NEVADA CONSOLIDATED COPPER COMPANY. Letter to the Stockholders, Feb. 3, 1910. N. p., n. d. (Gift of M. Guggenheim's Sons.)
- NEW YORK ACADEMY OF SCIENCES. Annals. Vol. 19, Pt. 1. New York, 1909. (Exchange.)
- NEW YORK STATE MUSEUM. Annual Report, 62d. Vols. 2, 3, 4. Albany, 1909. (Exchange.)
- NEW ZEALAND. MINES DEPARTMENT. Papers and Reports Relating to Minerals and Mining, 1909. Wellington, 1909. (Exchange.)
- ONTARIO. MINES BUREAU. General Index to the Reports, Vols. 1-16, 1891-1907. Toronto, 1909. (Exchange.)
- PAINT MANUFACTURERS' ASSOCIATION OF THE UNITED STATES. Report on Examination of North Dakota Test Fences, 1909. (Bulletin No. 25.) Philadelphia, 1909. (Gift of Paint Manufacturers' Association of the United States.)
- POSTULADOS DE LAS CLASES OBRERAS Y DE LOS DESVALIDOS Y PROLETARIOS Á PRESENCIA DE LA CIENCIA SOCIAL Y, EN ESPECIAL, DE LA ECONOMIA POLITICA. (Vol. II., Congreso Científico 1° Pan-Americano.) Santiago de Chile, 1909. (Gift of the Secretaria General, 4° Congreso Científico.)
- PUBLIC UTILITY OF WATER POWERS AND THEIR GOVERNMENTAL REGULATION. (Water-Supply Paper No. 238, U. S. Geological Survey.) By René Tavernier and M. O. Leighton. Washington, 1910. (Exchange.)
- RESULTS OF MAGNETIC OBSERVATIONS MADE BY THE COAST AND GEODETIC SURVEY BETWEEN JULY 1, 1908, AND JUNE 30, 1909. By R. L. Faris. (U. S. Coast and Geodetic Survey, Appendix No. 3—Report, 1909.) Washington, 1910. (Exchange.)

- RESULTS OF SPIRIT LEVELING IN ILLINOIS, 1896-1908, INCLUSIVE. (Bulletin No. 421, U. S. Geological Survey.) By S. S. Gannett and D. H. Baldwin. Washington, 1910. (Exchange.)
- SCIENTIFICALLY PREPARED PAINTS AND LAWS GOVERNING THEIR MANUFACTURE. By H. A. Gardner. Philadelphia, n. d. (Gift of Paint Manufacturers' Association of the United States.)
- SMITHSONIAN INSTITUTION. Annual Report, 1908. Washington, 1909. (Exchange.)
- SMITHSONIAN INSTITUTION. U. S. National Museum. Annual Report, 1909. Washington, 1909. (Exchange.)
- SOME IRON OXIDES AND THEIR VALUES. Philadelphia, 1910. (Gift of Paint Manufacturers' Association of the United States.)
- STUDY OF BASE AND BEARING PLATES FOR COLUMNS AND BEAMS. (Bulletin No. 35, University of Illinois, Engineering Experiment Station.) By N. Clifford Ricker. (Exchange.)
- THEORY OF DRIERS AND THEIR APPLICATION. (Bulletin No. 23.) Philadelphia, 1910. (Gift of Paint Manufacturers' Association.)
- U. S. CENSUS BUREAU. Report of the Director, 1908-09. Washington, 1910. (Exchange.)
- U. S. INTERSTATE COMMERCE COMMISSION. Annual Report of the Block Signal and Train Control Board, 2d, 1909. Washington, 1909. (Exchange.)
- U. S. LIBRARY OF CONGRESS. Duplicate Periodicals and Serials Available for Exchange, Jan., 1910. Washington, 1910. (Exchange.)
- Report of the Librarian, 1909. Washington, 1909. (Exchange.)
- Publications Issued since 1897. Washington, 1910. (Exchange.)
- Want List, Miscellaneous Publications, 1909. Washington, 1909. (Exchange.)
- UNIVERSITY OF CALIFORNIA. Exchanges Maintained by the University Press, Jan., 1910. Berkeley, 1910. (Exchange.)
- USES OF MINERAL OIL MIXED CONCRETE. By Albert Moyer. N. p., n. d. (Gift of Vulcanite Portland Cement Co.)
- ZWEI QUECKSILBERMANOMETER FÜR NIEDRIGE DRUCKE. Von Karl Scheel und W. Heuse. (Reprint Physikalisch-technische Reichsanstalt, Pt. 11, 1909.) (Gift.)

GIFT OF ENGINEERING AND MINING JOURNAL.

- AIRY, W. Origin of the British Measures of Capacity, Weight, and Length. (Institution of Civil Engineers. Proceedings, Vol. 177, Pt. 3.)
- ANDERSON, G. A. Some Aspects of Irrigation Development in Colorado. (Reprint Colorado Scientific Society, Vol. 9.)
- BAYLEY, V. Pneumatic Founding of Pier No. 6, Banas River Bridge, Nagda-Muttra State Railway. (Institution of Civil Engineers. Proceedings, Vol. 177, Pt. 3.)
- BORNEMANN, K. Die binären Metalllegierungen. 1909.
- BRUNSWICK, E. J. L'Électricité dans les mines applications diverses-extraction. 1910.
- CAMBRIDGE. Bridge Commission. Report, 1909.
- CANADA. MINES DEPARTMENT. Catalogue of Publications of the Geological Survey of Canada, 1909.
- Coal Fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia. 1909.
- Descriptive Sketch of the Geology and Economic Minerals of Canada. 1909.

- CANADA. MINES DEPARTMENT. Report on the Iron-Ore Deposits Along the Ottawa (Quebec side) and Gatineau Rivers. 1909.
- CONWAY, G. R. G. Aberdeen Main Drainage Works. Girdleness Outfall Scheme. (Institution of Civil Engineers. Proceedings, Vol. 177, Pt. 3.)
- GIBSON, A. H., and GWYTHIER, R. D. Effect of Varying the Degree of Saturation of the Air-Supply to a Suction Gas Producer. (Institution of Civil Engineers. Proceedings, Vol. 177, Pt. 3.)
- HOLDEN, H. C. L. Road Motors of the Present Day, and Some Unsolved Problems Connected with Them. (Institution of Civil Engineers. Proceedings, Vol. 177, Pt. 3.)
- ILLINOIS. LABOR STATISTICS BUREAU. Annual Coal Report, 27th. 1908.
- INSTITUTO GEOLOGICO DE MEXICO. Boletín No. 26. 1908.
- Parergones. Tomo III., No. 1, 1909.
- KNOWLES, A. J. Road Bridges Over the Nile at Cairo. (Institution of Civil Engineers. Proceedings, Vol. 177, Pt. 3.)
- MCCLUNG, R. K. Conduction of Electricity Through Gases and Radio-Activity. 1909.
- MERRIAM, J. C. Occurrence of Strepsicerine Antelopes in the Tertiary of Northwestern Nevada. (University of California, Bulletin of the Department of Geology, Vol. 5, No. 22, 1909.)
- MEXICO. Estado y del Despacho de Hacienda y Crédito público Secretaría Boletín de Estadística fiscal, Nos. 338, 339, 341. 1909.
- Resumen de la importación y de la exportación. Aug.-Oct., 1909.
- MINNEAPOLIS. City Engineer. Annual Report, 1907, 1908.
- MOWAT, M. Some Recent Grain Handling and Storing Appliances at the Mill-wall Docks. (Institution of Civil Engineers. Proceedings, Vol. 177, Pt. 3.)
- NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION. Bulletin No. 9, 1909.
- New York State Branch. Constitution and List of Members, 1908.
- NEW YORK STATE. LABOR DEPARTMENT. Annual Report of the Bureau of Labor Statistics, 26th. 1909.
- NEW ZEALAND. GEOLOGICAL SURVEY. Geology of the Whangaroa Subdivision. (Bulletin No. 8.) 1909.
- NEW ZEALAND. MINES DEPARTMENT. Papers and Reports Relating to Minerals and Mining. 1909.
- PENNSYLVANIA. MINES DEPARTMENT. Report. Part II.—Bituminous. 1907.
- REED, S. J. Design of Marine Steam Turbines. (Institution of Civil Engineers. Proceedings, Vol. 177, Pt. 3.)
- SMITHSONIAN INSTITUTION. Annual Report, 1908.
- SOCIÉTÉ L'INDUSTRIE MINÉRALE. Bulletin et comptes rendus, Nov.-Dec., 1909.
- LA TECHNIQUE MODERNE. (Supplement to Nov., 1909, number.)
- U. S. ARMY. Report of the Chief of Engineers, 1909.
- U. S. CENSUS BUREAU, DEPARTMENT OF COMMERCE AND LABOR. Forest Products of the U. S. (No. 10.) 1908.
- Bulletin No. 105. 1909.
- U. S. COMPTROLLER OF CURRENCY. Annual Report, 1909.
- U. S. INTERNAL REVENUE COMMISSION. Annual Report, 1909.
- U. S. GEOLOGICAL SURVEY. Annual Report of the Director, 30th. 1909.
- Bulletin 381-A (advance chapter); Nos. 395, 396, 397, 404, 405, 409, 411. 1909.
- Monograph. Vol 46. 1904.
- Professional Paper No. 65. 1909.

- U. S. GEOLOGICAL SURVEY. Water-Supply Papers Nos. 227, 233, 236, 238. 1909-1910.
- U. S. STEAM ENGINEERING BUREAU. Annual Report, 1909.
- UNIVERSITY OF ILLINOIS. Engineering Experiment Station. Fuel Tests with House Heating Boilers. (Bulletin No. 31.) 1909.
- UNWIN, W. C. Standardization and Its Influence on Engineering Industries. (Institution of Civil Engineers. Proceedings, Vol. 177, Pt. 3.)
- ZEITUNG KATALOG DER ANNONCEN EXPEDITION RUDOLF MOSSE. Ed. 43. 1910.

TRADE CATALOGUES.

- AMERICAN CONCRETE PILING CO., Philadelphia, Pa. Concrete piles for foundations, piers, wharves, and docks. 61 pages.
- CYANIDE PLANT SUPPLY CO., San Francisco, Cal. The Filtration of Slime with the Parrish Continuous Filter. Reprint from *Pacific Miner*. 16 pages.
- DINGS ELECTRO-MAGNETIC SEPARATOR CO., Milwaukee, Wis. Bulletin No. 21. Magnetic Separators. 20 pages.
- ISZARD-WARREN CO., Philadelphia, Pa. Scientific Instruments for the town-house, country place, travel, and sports. 48 pages.
- MASHEK ENGINEERING CO., New York, N. Y. Coal Briquetting machinery and plants. 56 pages.
- STEPHENS-ADAMSON MFG. CO., Aurora, Ill. *Conveying and Transmission*, Jan., 1910. A publication devoted to methods for the mechanical handling of materials and transmission of power. 24 pages.

United Engineering Society Library.

- EAGLE ALMANAC, 1909. Brooklyn, 1910. (Purchase.)
- HENDRICKS' COMMERCIAL REGISTER OF THE UNITED STATES. Ed. 18. New York, 1910. (Purchase.)
- HOW TO MAKE IMPROVEMENT THINNINGS IN MASSACHUSETTS WOODLANDS. By H. O. Cook. Boston, 1910. (Gift of Massachusetts State Forester.)
- REGISTER TILL PATENT MEDDELADE AF KUNGL. PATENTBYRÅN. 1885-1908, and Supplement to 1905. Stockholm, 1890-1909. (Purchase.)
- STUDY OF THE MASSACHUSETTS WOOD-USING INDUSTRIES. By H. Maxwell. Boston, 1910. (Gift of Massachusetts State Forester.)
- TRIBUNE ALMANAC, 1910. New York, 1910. (Purchase.)
- WORLD ALMANAC, 1910. New York, 1910. (Purchase.)

GIFT OF E. E. OLCOTT.

- ALBANY INSTITUTE. Transactions. Vol. 5. Albany, 1867.
- NEW YORK STATE. Adjutant General. Annual Report. Vol. 3. Albany, 1868.
- NEW YORK STATE ENGINEER AND SURVEYOR. Annual Report on Canals, 1862, 1864. Albany, 1863, 1865.
- Annual Report on Railroads, 1862, 1865. Albany, 1863, 1866.
- NEW YORK (STATE) RAILROAD COMMISSIONERS. Report. Vol. 1, 1885. Albany, 1886.
- SWEET, S. H. Documentary Sketch of New York State Canals. Albany, 1863.

TRADE CATALOGUES.

- CARNEGIE STEEL CO., Pittsburg, Pa.
- Steel Mine Timbers. Data and tables for the use of mining engineers. 46 pages.

CARNEGIE STEEL Co., Pittsburg, Pa.

Steel Sheet Piling. 16 pages.

Schoen Steel Wheels, No. I. 46 pages.

Schoen Steel Wheels. Designs and Specifications. 46 pages.

Carnegie Special Welding Steel. Carnegie Special Threading Steel. 40 pages.

Carnegie Steel Cross Tie and Duquesne Rail Joint. 61 pages.

Steel Sheet Piling. Types of construction and examples of installation. 64 pages.

Steel Mine Timbers. Types of construction and examples of installation. 30 pages.

MEMBERSHIP.

NEW MEMBERS.

The following list comprises the names of those persons elected as members who accepted election during the month of February, 1910:

Members.

Nelson G. Brayer,	Sharon, Pa.
Halsted Woodrow Caldwell,	Thomas, Ala.
Robert B. Carnahan, Jr.,	Middletown, Ohio.
Edwin E. Carpenter,	Syracuse, N. Y.
Harry Edward Ewing,	Worth, W. Va.
Thomas Francis Higgins,	Panulcillo, Coquimbo, Chile, South America.
James Macdonald Hyde,	Palo Alto, Cal.
Joseph Henry Ivey,	Quechisla, Bolivia, South America.
William Neilson,	Midas, Nev.
Philip Benjamin Osborn,	Johannesburg, South Africa.
William Clark Joseph Rambo,	Cainesville, Mo.
Charles Arthur Stewart,	Ithaca, N. Y.
Alfred Wood Stickney,	Cambridge, Mass.
Malcolm MacFarlan Thompson,	Ridgefield, N. J.
Karl M. Way,	Boston, Mass.
Leslie James Wilmoth,	Germiston, South Africa.

CANDIDATES FOR MEMBERSHIP.

The following persons have been proposed for election as members of the Institute during the month of February, 1910. Their names are published for the information of members and associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or unfavorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Council, which has the power of final election.

Members.

Frank H. Blackmar,	Kansas City, Mo.
Frederick J. Brulé,	Tooele, Utah.
Lowell Huntington Brown,	Catasauqua, Pa.

Dean Stanley Calland,	Pachuca, Hidalgo, Mexico.
Frederick G. Clapp,	Pittsburg, Pa.
R. C. Crawford,	McKeesport, Pa.
Herbert H. Crease,	Ibagué, Colombia, S. A.
Justin Sarsfield De Lury,	Moscow, Idaho.
Siang Hye Eu,	Nanking, China.
Richard Eustice,	Moonta Mines, So. Australia.
David Morrill Folsom,	Palo Alto, Cal.
Heitaro Fujita,	Dojima, Osaka, Japan.
Edmund Cecil Harden,	Washington, D. C.
Charles Holding,	Collinsville, Ill.
Kazuye Kibe,	Tokyo, Japan.
Richard Kleesattel,	Seattle, Wash.
Grenville Lewis,	Pineville, Ky.
David Sebastian Longacre,	Dragon, Utah.
Harry Bertine Meller,	Pittsburg, Pa.
Peter A. Newton,	South Chicago, Ill.
Charles G. Osborne,	South Chicago, Ill.
Hugh Davidson Pallister,	Cleveland, Ohio.
Robert Boyd Stewart,	Toronto, Canada.
Stephen Taber,	Charlottesville, Va.
Harry S. Thayer,	Colorado Springs, Colo.
William P. Wescott,	Jersey City, N. J.
Charles S. Witherell,	Newark, N. J.

Associate.

George B. Chelius,	New York, N. Y.
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Change of Status.

L. H. Winkler,	Johnstown, Pa.
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CHANGES OF ADDRESS OF MEMBERS.

The following changes of address of members have been received at the Secretary's office during the month of February, 1910. This list, together with the list published in *Bulletin No. 38*, February, 1910, therefore, supplements the annual list of members corrected to Jan. 1, 1910, and brings it up to the date of Mar. 1, 1910. The names of members who have accepted election during the month (new members) are printed in *italics*.

ARMAS, MILTIADES TH.....	25 Blvd. Carnot, Alger, Algeria, France.
BASSETT, WILLIAM H., Met.....	American Brass Co., Waterbury, Conn.
BATESON, CHARLES E. W.....	20 W. 48th St., New York, N. Y.
BAUMGARTEN, KARL.....	P. O. Box 268, Tucson, Ariz.
BEL, J. MARC.....	90 Rue d'Amsterdam, Paris, France.
BLACKMER, WILLIAM D., Care H. M. Blackmer, 111 Broadway, New York, N. Y.	
BRADLEY, OLIVER Ū.....	Muskogee, Okla.
*Brayer, N. G., Asst. Supt....	National Malleable Castings Co., Sharon, Pa. '10.

- BURRELL, FREDERICK P.....Apartado 5, Nacozari, Son., Mexico.
 CAETANI, GELASIO.....1019 Crocker Bldg., San Francisco, Cal.
 CALDERWOOD, JAMES M., Cons. Min. Engr., 105 Exploration Bldg.,
 Johannesburg, Transvaal, So. Africa.
 *Caldwell, Halsted W., Min. Engr.....Thomas, Ala. '10.
 *Carnahan, Robert B., Jr., Met., Genl. Supt., American Rolling Mill Co.,
 Middletown, Ohio. '10.
 *Carpenter, Edwin E., Min. Engr.....120 W. Willow St., Syracuse, N. Y. '10.
 CLARK, FRED. 107 Lick Bldg., San Francisco, Cal.
 CLARK, GEORGE M., Mgr.....Sherman Mining & Milling Co., Placerville, Cal.
 COLE, FRANK L.....P. O. Box 197, Vladivostok, Siberia.
 COMSTOCK, THEODORE B., Engr., Board of Public Utilities, City Hall,
 Los Angeles, Cal.
 CUMMINGS, WILLIAM N.....P. O. Box 268, Tucson, Ariz.
 DICK, JAMES C., Care Cons. Mercur G. M. Co., P. O. Box 1418,
 Salt Lake City, Utah.
 DICK-CLELAND, A. F.....Care Apartado 181, Guadalajara, Jal., Mexico.
 DONOHUE, PATRICK J.....66 W. 3d South St., Salt Lake City, Utah.
 DORR, JOHN VAN N.....728 Equitable Bldg., Denver, Colo.
 DRAPER, CARL H.....Hacienda San Vincente, San Martin Hidalgo, Jal., Mexico.
 DRAPER, FRED W.....Care Hotel Savoy, London, England.
 DUFFIELD, MORSE S.....311 Dooly Bldg., Salt Lake City, Utah.
 ELMER, WILLIAM W., Care Cia. Real del Monte y Pachuca,
 Pachuca, Hgo., Mexico.
 EMLAW, HARLAN S., Care Utah Consolidated Mining Co.,
 Bingham Canyon, Utah.
 *Ewing, Harry E., Transitman.....Worth, W. Va. '10.
 FORBES, D. L. H., Min. and Met. Engr., Care El Tigre Mining Co., S. A.,
 Yzabal, Son., Mexico.
 FRANCK, ALBERT C.....3408 Sixth St., San Diego, Cal.
 FUDGE, THOMAS.....32 W. 38th St., Bayonne, N. J.
 GEPPERT, R. M.....Post Station, Atbasar, Siberia.
 GOUYARD, GUSTAVE M.....201 W. 79th St., New York, N. Y.
 GRANSTEDT, FRANK H., Mine Mgr., Mt. Bischoff Extended Tin Mining Co.,
 Waratah, Tasmania.
 GREENIDGE, SAMUEL M., Care Greenidge & Lee, P. O. Box 344,
 Cananea, Son., Mexico.
 GRIFFITH, WILLIAM V.....Geyserville, Cal.
 GRISWOLD, WILLIAM T., Geol., Philadelphia Co., 435 Sixth Ave., Pittsburg, Pa.
 GRUNSKY, CARL E., JR.....45 Broadway, New York, N. Y.
 HAEHL, HARRY L., Duryea, Haehl & Gilman, 1314 Humboldt Bank Bldg.,
 San Francisco, Cal.
 HARRIS, HAROLD J., Care Keeling, Teale, Harris & Co., Ltd.,
 12 Ravenscourt Sq., London, W., England.
 HAWKINS, TANCRED.....Victor Gold Mine, P. O. Box 542, Victor, Colo.
 HEDLEY, ROBERT R.....P. O. Box 812, Victoria, B. C., Can.
 HERR, IRVING.....Apartado 49, Guanajuato, Mexico.
 HIGGINS, EDWIN.....Columbia Trust Bldg., Los Angeles, Cal.
 *Higgins, Thomas F., Smelter Supt., Central Chile Copper Co.,
 Panulcillo, Coquimbo, Chile, So. Amer. '09.
 HINDSHAW, HENRY H., Geol. and Min. Engr., 153 Coolidge Ave., Syracuse, N. Y.
 HOAR, FREDERIC W.....P. O. Box 959, Globe, Ariz.
 HODGE, BENJAMIN.....Instructed to hold all mail.

- HOBAGEN, GEORGE.....La Paz, Bolivia, So. Amer.
 HUGHES, WILSON W., Cia. de Real del Monte, Hacienda de Loreto,
 Pachuca, Hgo., Mexico.
 *Hyde, James M., Min. Engr.....334 Lincoln Ave., Palo Alto, Cal. '07.
 *Ivey, Joseph H., Min. Engr., Care Aramayo, Francke & Co.,
 Quechisla, Bolivia, So. America, via Buenos Ayres. '09.
 JACK, JAMES, Care Institution of Mining and Metallurgy, Salisbury House,
 London, E. C., England.
 JEFFS, LEWIS A.....309 Dooly Block, Salt Lake City, Utah.
 KAEDING, GEORGE L.....Kaeding Const. Co., Eureka, Nev.
 KEITH, FRANK A., Min. Engr.....731 Central Bldg., Los Angeles, Cal.
 KIRKCALDY, NORMAN M., 37 Billiter Bldg., Billiter St., London, E. C., England.
 LANGLEY, SETH S.....229 Blatchley Ave., New Haven, Conn.
 LAUDIG, O. O.....Care Emery Keller, R. F. D. 3, Battle Creek, Mich.
 LEAVELL, JOHN H.....Care Buffalo Mine, Cobalt, Ont., Can.
 LEE, J. HENRY23 W. 20th St., Baltimore, Md.
 LIDDELL, CHARLES A.....Battle Mountain, Nev.
 LINNEY, WILLIAM H.....1234 Westlake Ave., Los Angeles, Cal.
 LOUIS, DAVID A.....123 Pall Mall, S. W., London, England.
 LUNT, HORACE F.....Gazette Bldg., Colorado Springs, Colo.
 MCAULEY, DUNCAN F., Great Boulder Perseverance G. M. Co.,
 P. O. Box 94, Fimiston, West. Aust.
 MCGREGOR, J. MURRAY, Care Geological Survey and Museum, 33 George Sq.,
 Edinburgh, Scotland.
 MCKIM, JOHN W.....532 Dooly Block, Salt Lake City, Utah.
 McLINTOCK, ARCHIBALD.....Hermon House, Hermon, N. Y.
 MAYER, PAUL H.....1126 Lafayette St., Denver, Colo.
 MEIN, WILLIAM W.....Box 1145, Johannesburg, Transvaal, So. Africa.
 MILLER, EMORY T.....Care United Fruit Co., Bocas del Toro, Panama.
 MILLER, JESSE W.....30 W. 44th St., New York, N. Y.
 MILLS, RONALD V. A.....Care F. C. Mills, 20 Union Sq., New York, N. Y.
 MORRIS, FRANK H., Cons. Civ. and Min. Engr., 8 Union Court, Old Broad St.,
 London, E. C., England.
 *Neilson, William, Min. Engr.....Gold Circle Mining District, Midas, Nev. '10.
 NICHOLLS, JOHN C.....Dutch Flat, Placer Co., Cal.
 NICHOLS, RALPH.....Latest Out Mine, Gilmore, Lemhi Co., Idaho.
 NORTH, WHEELER O., Care British Malaysian Rubber Co.,
 Goebilt, Sarawak, Borneo, Dutch East Indies.
 OLIVER, ROBERT S., Mgr.....Utah-Apex Mining Co., Bingham Canyon, Utah.
 *Osborn, Philip B., Tech. Staff, General Mining and Finance Corp.,
 Box 1212, Johannesburg, Transvaal, So. Africa. '10.
 PAINE, FREDERIC C., Civ. Engr.....Care Paine & Muldrow, Okanogan, Wash.
 PALMER, ROBERT E., Chief Min. Engr., Rio Tinto Co., Rio Tinto Mines,
 Prov. of Huelva, Spain.
 PALMER, WILLIAM J. A.....P. O. Box 109, Mazatlan, Sinaloa, Mexico.
 PARRISH, SAMUEL F.....Care Consolidation Copper Mines, Parker, Ariz.
 PETERSSON, G. WALFRID.....Engelbrecktsgratan 43 B, Stockholm, Sweden.
 POMEROY, WILLIAM A., Care New Jersey Zinc Co., 35 Wall St., New York, N. Y.
 PORTER, JESSE C., Santa Rita Mine, Nicaragua, via Silverstein and Kelting,
 924 Maison-Blanche Bldg., New Orleans, La.
 *Rambo, William C. J., Supt., Grand River Coal & Coke Co., Cainville, Mo. '10.
 REDMAYNE, R. A. S., Chief Inspector of Mines, Home Office, London, England.

- ROBERTS, EDWARD J., Supt., Spokane International Ry. and
Corbin Coal & Coke Co., Spokane, Wash.
- ROPER, LEVERETT S.....541 N. Rodney St., Helena, Mont.
- ROSE, HUGH.....Cia. de Santa Gertrudis, Pachuca, Hgo., Mexico.
- ROSE, FRANK A., Cons. Engr.....Spokane Club, Spokane, Wash.
- RULE, J. ARTHUR, Asst. Supt., Cia. Metalurgica de Torreon, Apartado 260,
Torreon, Coah., Mexico.
- SAMPLE, CLARENCE C.....5 W. 65th St., New York, N. Y.
- SANDERS, W. E.....Hotel Cumberland, Los Angeles, Cal.
- SCAIFE, MARVIN F.....514 North Ave., Allegheny, Pa.
- SCOTT, EDWARD H.....517 Crocker Bldg., San Francisco, Cal.
- SHERBERD, JOHN M.....340 Spring Garden St., Easton, Pa.
- SKEELS, LEE H.....1239 S. Farwell St., Eau Claire, Wis.
- SMITH, J. WILLIAM, Asst. Genl. Mgr.....Solway Process Co., Syracuse, N. Y.
- SMITH, LLOYD B.....Carnegie Technical Schools, Pittsburg, Pa.
- SMITH, WILLIAM A., Care United Zinc & Chemical Co., 1012 Baltimore Ave.,
Kansas City, Mo.
- SNOW, FREDERICK W.....Ray Cons. Copper Co., Kelvin, Ariz.
- SOPEB, EDGAR K., Instructor in Econ. Geol., Univ. of Minn., Minneapolis, Minn.
- SPIES, ALBERT, Mgr. Dir.....*Foundry News*, 50 Church St., New York, N. Y.
- STANFORD, RICHARD B., Siempre Viva Mining Co., via Cape Gracias,
Nicaragua, C. A.
- STEEL, DONALD.....120 Oak Ave., Ithaca, N. Y.
- STENGER, EDWARD L.....Mountain Copper Co., Keswick, Shasta Co., Cal.
- *Stewart, Charles A., Instructor in Geol., Cornell University, Ithaca, N. Y. '10.
- *Stickney, Alfred W., Teaching Fellow at Harvard, 12 Channey St.,
Cambridge, Mass. '10.
- STROUT, ERNEST A., Care Cia. de Santa Gertrudis, S. A., Pachuca, Hgo., Mexico.
- TAYLOR, ALBERT W., Genl. Mgr., Korean Exploration Co., Chiksan Mines,
Chiksan, Korea.
- THOMPSON, JAMES S., Supt. 1st Div., Colorado Fuel & Iron Co., Trinidad, Colo.
- *Thompson, Malcolm M., Min. Engr.....P. O. Box 26, Ridgefield, N. J. '10.
- TOWER, GEORGE W., JR.....Socorro Mines, Mogollon, N. M.
- TROTZ, J. O. EMANUEL.....Svanevik, Ronneby, Sweden.
- VALLAT, BENJAMIN W., Supt.....Newport Mining Co., Ironwood, Mich.
- VIDLER, LOUIS W.....Lookout Mt., Golden, Colo.
- VIGGERS, WILLIAM.....P. O. Box 75, Guadalupe, Dur., Mexico.
- WALTER, E. W., Genl. Mgr.....Banker Mining & Tunnel Co., Winfield, Colo.
- *Way, Kurt M., Min. Engr.....93 Broad St., Boston, Mass. '10.
- WEBBER, GEORGE E.....P. O. Box 1056, Johannesburg, Transvaal, So. Africa.
- WEIGALL, ARTHUR R., Genl. Mgr.....Kapsan Mining Co., Kapsan Mine, Korea.
- WELHAVEN, ALF., Genl. Mgr., Oriental Consolidated Mining Co.,
Pukelin, Unsan, Korea.
- WELLS, FRANK B.....958 Valencia St., Los Angeles, Cal.
- WHITE, EDMOND A.....Port Kembla, N. S. W., Aust.
- WHITE, RUSH J.....Wardner, Idaho.
- WILDER, FREDERICK B.....Santa Rita, N. M.
- WILLIAMS, J. M., JR., Supt. Mining Dept., Cia. Metalurgica Mexicana,
Apartado 132, San Luis Potosi, Mexico.
- WILLIAMS, JOHN R., Care Standard Bank of So. Africa, 10 Clements Lane,
London, E. C., England.
- *Wilmoth, Leslie J., Chief Assayer, Simmer & Jack Proprietary Mines, Ltd.,
Box 192 Germiston, Transvaal, So. Africa. '09.

WILSON, ELWOOD J.....Care The Stratford, 242 Powell St., San Francisco, Cal.
WOODS, CLARENCE.....Instructed to hold all mail.
WRAITH, WILLIAM, Met. and Supt., Washoe Smelter,
Anaconda Copper Mining Co., Anaconda, Mont.
YEANDLE, WILLIAM H., JR., Care Cia. de Real del Monte y Pachuca,
Barran Mine, Pachuca, Hgo., Mexico.
ZELLER, HOWARD P.....1118 So. 16th St., Birmingham, Ala.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address on Records, from which Mail has been Returned.
Alexander, George E.,	Sparta, Ore.
Andersen, Carl,	Johnnie, Nev.
Badger, Harry S.,	Goldboro, N. S., Canada.
Bartocchini, Astolfo,	214 E. 90th St., New York, N. Y.
Bassett, Thomas B.,	Cumpas, Sonora, Mexico.
Batchelder, Joseph F.,	54 1st St., Portland, Ore.
Bellam, Henry L.,	Reno, Nev.
Bouchelle, James F.,	22 Duncan Ave., Jersey City, N. J.
Brown, Frank H.,	Coppermount, Alaska.
Campe, Jose,	Mexico City, Mexico.
Cragoe, A. Spencer,	Vencedora, Mexico.
Daniel, Mark,	United Elkhorn Mines, Baker City, Ore.
Derby, Harry S.,	184 Monroe St., Chicago, Ill.
Dickson, George H.,	Lethbridge, Alberta, Canada.
Donnewald, Albert H.,	3709 Finney Ave., St. Louis, Mo.
Dougherty, Clarence E.,	41 Wall St., New York, N. Y.
Downs, M. E.,	25 Broad St., New York, N. Y.
Ekberg, Benjamin P.,	Johannesburg, Transvaal, So. Africa.
Field, Wilfrid B.,	Mexico City, Mexico.
Fitch, Frank,	Black Mt. Min. Co., Magdalena, Mexico.
Foster, Lewis E.,	Utah Copper Co., Garfield, Utah.
Gaines, Ambrose P.,	Dayton Coal & Iron Co., Dayton, Tenn.
Gee, Emerson,	Reno, Nev.
Geppert, Richard M.,	Ray, Ariz.
Hand, Carlton H.,	Butte, Mont.
Hunt, Thatcher R.,	Iron Mt., via Keswick, Cal.
Jewett, Eliot C.,	2918 Morgan St., St. Louis, Mo.
Kow, Tong Sing,	Shanghai, China.
McCan, E. K.,	Braden Copper Co., Graneros, Chile, S. A.
Mildon, Reginald B.,	Nacozari, Son., Mexico.
Moulton, Herbert G.,	Cobalt, Ont., Canada.
Muir, Thomas K.,	Portland, Ore.
Perkins, Walter G.,	McGill, Nev.
Piper, John W. H.,	Buenos Ayres, Argentine Rep., S. A.
Potter, J. A.,	41 W. 124th St., New York, N. Y.
Sandifer, Harmer C.,	El Oro, Mexico.
Schneider, Albert F.,	112 Riverside Drive, New York, N. Y.
Scott, Winfield G.,	Long Beach, Cal.
Sevier, John C.,	Winnemucca, Nev.
Skelding, Joseph F.,	Embreeville, Tenn.
Thomas, Richard A.,	43 Wall St., New York, N. Y.

Trerise, Josiah H. Box 2086, Johannesburg, South Africa.
 Weddle, Joseph H., San Juancito, Honduras, C. A.
 Wilson, Odell, Shingle, Cal.
 Wolfe, Burton L., Ely, Nev.
 Yates, Edwin F., P. O. Box 25, Rawhide, Nev.
 Young, William, Kenora, Ont., Canada.

NECROLOGY.

The deaths of the following members have been reported to the Secretary's office during the month of February, 1910:

Date of Election.	Name.	Date of Decease.
1902.	*Wager Bradford,	_____
1903.	*R. Prewitt Coleman,	February 5, 1910.
1876.	*John W. Hoffman,	January 18, 1910.
1874.	*Charles B. Parsons,	January 28, 1910.
1900.	*Ferd. H. Regel,	January 18, 1910.
1888.	*William H. Schlemm,	_____
1882.	*A. B. Wood,	January 24, 1910.

BIOGRAPHICAL NOTICES.

Ottokar Hofmann was born in 1843 at Ruskberg, a mining town in Hungary, where his ancestors, for several generations, had been miners or metallurgists. He was educated in Vienna and at the Royal Saxon Mining Academy of Freiberg, where he was graduated in 1866. In 1867, he came to the United States, and formed with the late Guido Küstel a partnership, which at first conducted an assay-office only, but subsequently established metallurgical testing-works—the first on the Pacific Coast. At that time, the Washoe pan-amalgamation (with or without chemical reagents) and the so-called “Freiberg” barrel-amalgamation were practically the only processes employed in treating the silver-bearing ores of the Comstock, and of other districts in Nevada. Messrs. Küstel and Hofmann did much to aid the introduction of lixiviation processes, such as the Patera, and especially the Plattner chlorination. In 1869, Mr. Hofmann erected lixiviation-works at La Dura, in Sonora; and the success of this undertaking (after many difficulties had been overcome) led to his construction at La Trinidad and San Marcial, in the same State, of similar plants, which were successfully operated for a considerable period. The circumstance that changes in economic conditions and the development of

new processes, such as the cyanide process, have since superseded, to some extent, these earlier methods, does not detract from his merit as a pioneer.

Returning to California, Mr. Hofmann was engaged for several years as metallurgist in amalgamating-mills and chlorination-works in Nevada and California. In 1878, he was employed to treat the rich and complex concentrates of certain mines at Monitor, Cal. This problem he solved successfully by roasting the ore with salt, extracting the gold by chlorination, and leaching the residuum. His success in this case led to his engagement for similar work in connection with many Western and Mexican mining enterprises. In 1888, he was employed to experiment with the ores of the San Francisco del Oro mine, near Parral, Mex.; and the result of this work appeared in a series of articles, published in 1889 by the *Engineering and Mining Journal*, which constituted an important contribution to metallurgical literature. In 1890, he became managing director of the North Mexican Mining & Milling Co., a position which he held until 1894, when he was engaged by the Hidalgo Mining Co. to rebuild and remodel its lixiviation-works at Parral. In 1895, he was called by the Kansas City Smelting & Refining Co., to take charge of its copper-extraction department. In this work, he developed the Hofmann process for the production of pure copper sulphate, a description of which may be found in Vols. VIII. and X. of *Mineral Industry*. In 1899, he was appointed chemical director of the United Zinc & Chemical Co., for which he built a large plant at Argentine, Kan., where he remained until 1905. He then resigned, intending to devote his time to experimental work and writing. He was engaged in this work for two years, during which time he discovered a new method of making red oxide pigments of unusual brilliancy. He also wrote a number of articles and completed his well-known treatise on *The Hydrometallurgy of Silver*.

A sedentary life, however, did not suit his active temperament, and in 1907 he decided to go back to Mexico, accepting an offer from the Topia Mining Co., of New York. Topia is a small mining-camp in the precipitous mountains of Durango, more than 100 miles from a railroad. The place is remote, being reached only by difficult trails, and it was almost impos-

sible to secure proper food and accommodations. Though he accomplished what he undertook to do—to remodel a run-down lixiviation-plant and make it pay—he was too old a man at that time to undergo such hardships, and his health gave way. He returned to his home in Kansas City, but last summer his health broke down completely, and he died Dec. 24, 1909.

Mr. Hofmann became a member of the Institute in 1884, but his only contribution to the *Transactions* was a paper on Trough-Lixiviation (*Trans.*, xvi., 662), the ability and value of which increases our regret that he was not spared to give us further fruits of his genius and experience.

For much of the foregoing notice, I am indebted to the excellent notice of Mr. Hofmann published in the *Engineering and Mining Journal* of Jan. 22, 1910. But I have also personal knowledge of his good work through many years.—R. W. R.

Israel Wistar Morris, who was born in 1829, was one of the pioneer operators in the anthracite-regions of Pennsylvania. Not regarding himself as strictly a mining engineer, he was, nevertheless, much interested in the Institute, which he joined in 1875, and subsequently became a life associate. Mr. Morris died, full of years and honors, Dec. 18, 1909.

Charles B. Parsons was born Feb. 26, 1830, at Benson, Vt., but during his childhood he went with his parents to Michigan, where he received a public-school education. In the War of the Rebellion, he served with the rank of lieutenant, and at its close, took charge of a small silver-lead mine near Northampton, Mass. In 1867 he removed to Missouri, where he became, and remained for nearly 43 years (down to a time not long before his death), the resident manager of the St. Joseph Lead Co., having its mines and reduction-works at Bonne Terre. When he took charge of it, the property showed only an irregular multitude of separate shallow surface-pits, with a few hand-jigs for concentrating the product; and the annual product was scarcely 100 tons of marketable galena. With admirable courage and prescience, he did for this mineral deposit what W. B. Cogswell did a little later for Mine La Motte—namely, established by borings the existence of large bodies of low-grade ore (galena, disseminated in limestone), organized

the exploitation of these masses on a large scale, and provided suitable means for the concentration of the crude product, as well as for its metallurgical treatment. In the execution of this scheme, he embodied many features of audacious originality, which subsequently won for him a deservedly high reputation as a mechanical and metallurgical engineer. But in the beginning, all novelties in plan served only to hinder the acquisition of the needed capital, and the years of Mr. Parsons's early experiments were years of financial struggle also. Moreover, he had to secure railroad connections for his works—a sufficiently difficult and costly matter by itself. And when, in 1883, his first mill was destroyed by fire, it seemed as if he had suffered a final defeat. But this catastrophe proved to be a blessing in disguise; for by that time the merits and prospects of his undertaking had become sufficiently known to command financial support; and he had the opportunity to replace the old works—a heterogeneous conglomeration of the results of successive experiments and the accretions required by successive stages of growth—with a building of ample capacity, expressing in every detail his matured solution of the special problem which he had so long and thoroughly studied.

Mr. Parsons had become a member of the Institute very early in its history—in 1874; and in 1886, in connection with the second St. Louis meeting, he had the opportunity to welcome at Bonne Terre a large party of his fellow-members, and to exhibit to them his completed works, in successful operation. The occasion was professionally memorable. The visitors had never before seen a mill for crushing and concentration in which there was not a single piece of overhead shafting—all power being transmitted from below, without strain to the building. Moreover, Mr. Parsons's improvements in concentrating-machinery attracted great interest; and, above all, his bold application of the principle of jiggging, etc., without sizing, challenged a lively discussion, which may be found in the *Transactions* of the Institute. It seems to have been shown that, whether his system was suitable for general ore-dressing or not, it worked well for the case which he had in hand, and which was not complicated by the presence in troublesome quantity of other minerals than the valuable galena, and the worthless limestone through which it was dis-

seminated. At all events, he made it pay; and when, in 1909, he was succeeded as manager by his son, the company's land had increased to more than 20,000 acres; its seven mines supplied two concentrating-mills, each of the capacity of 1,500 tons daily; it had the largest lead-smelting plant in the Mississippi valley; its annual output of lead exceeded 30,000 tons; its original narrow-gauge railroad had been replaced with 75 miles of first-class standard-gauge; it had built the three model towns of Bonne Terre, Herculaneum, and Leadwood; besides paying for all these improvements, it had distributed more than \$6,000,000 in dividends; and its assured prospects commanded a very high price for its stock.

Such a record is a monument; and we cannot be surprised that the man who built it had little time for anything else. Mr. Parsons made no contributions to the *Transactions* of the Institute, of which he was a member for 35 years. Yet he did the next best thing, by throwing open to its members at all times the results of his experience, and thus indirectly furnishing the materials for many a professional paper to which he did not put his own name. A hasty glance over our volumes reveals papers by Prof. G. C. Broadhead (v., 100), Prof. C. P. Williams (v., 314), and Prof. H. S. Munroe (xvii., 564 and 687), the data for which must have been derived, either through the direct contribution or by the cordial permission, of Mr. Parsons; and, in addition to these, there are other contributions, discussing the practice or the apparatus introduced by Mr. Parsons, and evincing the wide-spread professional interest aroused by his work.

In reviewing the careers of such men, I am often tempted to believe that there is a natural law, according to which retirement from business is shortly followed by retirement from earthly life altogether. Probably the truth is, that our laborious and busy "captains of industry" cannot bear to lay down their responsibilities until the last moment, and then die out of harness, as they would have died in harness if they had labored a little longer. At all events, Mr. Parsons died at his residence in Riverside, Mo., Jan. 28, 1910—not long after he had retired from his life-long work, and before he had had opportunity to enjoy the period of honorable ease to which that work so fully entitled him.—R. W. R.

Harvey A. Shipman was born in 1854 at Waukan, Wis., and received a college education in that State. He began work as a mining engineer in California, where he had charge for several years of the Searles properties. In 1899, he was called to Colorado, by T. A. Rickard, to take charge of Stratton's Independence mines, and remained in that position under the subsequent management of John Hays Hammond. In 1902, he went to Australia for Messrs. Bewick, Moreing & Co., of London, and managed some of their Australian properties, at which he is said to have broken the record for economy in mining and milling. In 1905, he returned to Denver, Colo., and engaged in general practice as a consulting engineer. In 1908, he consented to take charge of a mine in West Africa, where he contracted the fever from which he never fully recovered. Returning to this country broken in health, he died at Denver, Jan. 3, 1910. He had been a member of the Institute since 1899.

William H. Singer was born Oct. 2, 1835, at Pittsburg, Pa., and educated in the public schools and the Western University of that city. As a youth, he entered the employ of G. & J. H. Schoenberger & Co., who had begun in 1833 the manufacture of blister-steel in Pittsburg. A few years later, he became a member of the firm of Singer, Nimick & Co., which had been organized as Singer, Hartman & Co. in 1848, by his oldest brother, Mr. John Singer, and which, as early as 1853, was already manufacturing crucible cast-steel of high grade (see paper of William P. Shinn, "Pittsburg, Its Resources and Surroundings," *Trans.*, viii., 18). In 1860, he became the head of the firm, and retained that position until, in 1900, the concern was absorbed in the Crucible Steel Company of America, of which he was a director until his death, Sept. 5, 1909. Mr. Singer was also one of those who organized the Pittsburg Bessemer Steel Co., which built the Homestead Steel Works, and, after these works were purchased by Andrew Carnegie, served as a director of the Carnegie Steel Co.

In the course of his practical business experience, Mr. Singer made several inventions of value, for some of which he received U. S. patents. Among these was the "rolling coulter machine," now universally employed for rolling the bevel on plow-coul-

ters and harrow-disks; and also a method of compressing the liquid steel ingots designed for the manufacture of circular saws, whereby the seams liable to occur on the teeth, which caused split teeth, were eliminated. Additional patents relating to the manufacture of plow-steel, etc., were very valuable to Singer, Nimick & Co., and other licensees.

Mr. Singer was a life-long resident of Pittsburg, and influential in its social, religious, charitable, and municipal affairs. He was one of those leaders of American metallurgical industry who recognized the importance of this Institute, and gave to it their cordial support, at a time when such support was essentially needed. He became a member in 1873, when the young society numbered about 200, and when such names as his were not only potent aids to its further growth, but promises of that cordial co-operation between the theoretical students of mining and metallurgy, and the practical managers of mining and metallurgical operations, to which the usefulness of the Institute has been so largely due. And he supported us to the last in the same loyal spirit in which he joined us at the beginning. —R. W. R.

Application of Descriptive Geometry to Mining-Problems.

BY JOSEPH W. ROE,* NEW HAVEN, CONN.

(Pittsburg Meeting, March, 1910.)

MANY questions arising in the work of the mining engineer may be solved quickly and with sufficient accuracy by the methods of descriptive geometry; but, unfortunately, this subject is more often considered from a mathematical view-point than as an effective tool for solving practical problems. Some of the principles involved are merged into the ordinary operations of mechanical drawing, and are used unconsciously by the engineer in his every-day work. The rest are stowed away on the book-shelf with his forgotten or rarely-used college text-books. One reason for this condition of "innocuous desuetude" may lie in the unfortunate and often cumbersome notation which it has been found necessary to introduce. If some of these principles can be recalled to the engineer's attention in terms of every-day use they may prove of practical bearing.

Recently, in talking with several mining engineers, I used some of the drawing-room methods of a machine-designer, to the evident surprise of those around me. These men were perfectly familiar with the methods, but their application to mining-work had not occurred to them. At their suggestion the present paper is offered, not in any way as a treatise, but merely to suggest a certain point of view, in hope that it may lead others far more familiar with mining-problems to pursue the subject further.

I. TO FIND THE STRIKE.

As the simplest and most fundamental problem, let it be required to find the strike of a vein when the location and elevation of three points on the outcrop are known. It will be assumed for the present that the vein is a plane.

* Sheffield Scientific School, Yale University.

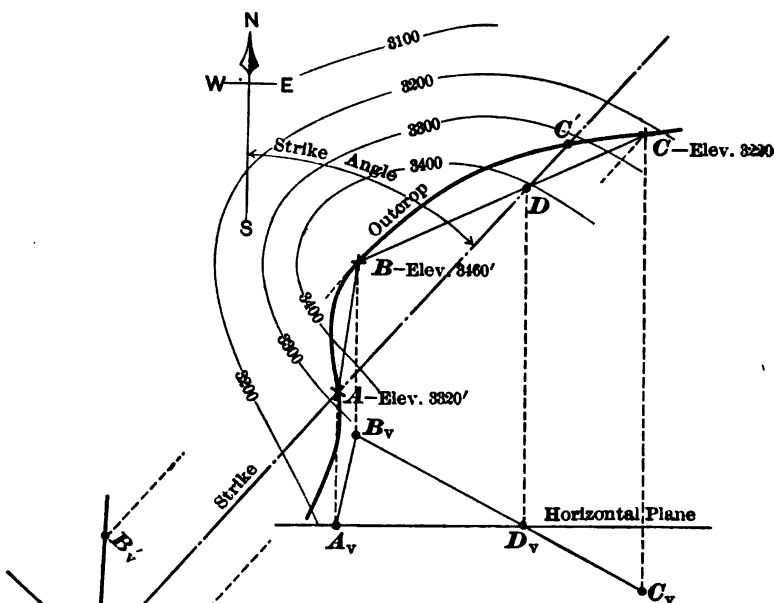


FIG. 1.

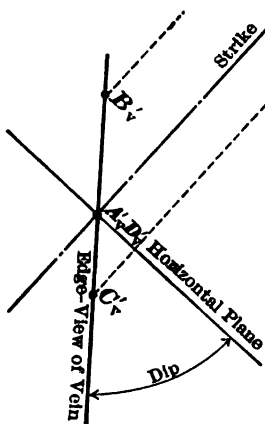


FIG. 2.

In Fig. 1 let A , B , and C be three points on an outcrop, their elevations, as found by observation or shown by contour-levels, being as noted. Connect A and B , B and C , giving the plan-view of two lines lying in the plane of the vein. If a side-view be drawn, as shown beneath the plan, A , B , and C will appear as A_v , B_v , and C_v (the v -subscript indicating a vertical projection), and a horizontal plane through A will appear as a horizontal line through A_v . D_v , where the line $B_v C_v$ cuts the plane, is the side-view of a point in the vein on the same level as A . Projecting up to the line BC , this point appears in the plan-view at D . Two points in the plan-view, such as A and D , on the same level and both in the vein, determine the strike. A saving in line-work might be made by drawing the

line representing the side-view of the horizontal plane through A itself instead of through its projection, A_v , using the same construction otherwise. It is clearer, for the present purpose, to show the side-views separately instead of partly super-imposed.

If a point on the outcrop at the same level as A can be located, as C' , the line from A to C' will at once give the strike. A third point, B , will, however, be necessary to determine the dip, as a plane cannot be located with less than three points.

II. TO FIND THE DIP.

Having found the strike, take a side-view of the vein looking up the strike-line. The points A , B , C , and D and the plan-view will appear as shown. The line through B'_v , C'_v , etc., Fig. 2, is the edge-view or end-projection of the vein, and the dip is, of course, the angle included between this and the horizontal plane.

The dip might also be found by passing a vertical projecting-plane through B perpendicular to the line of strike, and then revolving the line of intersection of this plane and the vein into the plane of the paper. This is the characteristic method of descriptive geometry, but when the engineer wants to detail some part which stands at odd angle with the rest of his drawing, as, for instance, a hand-hole plate or a sky-light, he does not adhere rigidly to his right-angled projections, but draws an oblique view looking squarely at the detail, showing it directly and giving the dimensions without any troublesome revolvings. By taking a side-view up the line of strike many problems which otherwise might be troublesome are reduced to the very simplest terms. As examples of this take the following:

III. DEPTH OF A SHAFT.

Given the points on an outcrop as before, how deep must a shaft be sunk at some point, S , to strike the vein?

The strike and dip having been found, we have the side-elevation of the vein, as shown in Fig. 3. The point, S , from which the shaft is to be sunk appears as S_v at its proper elevation, and the depth of the shaft is obtained at once by scaling $S_v E_v$.

IV. LENGTH OF A TUNNEL.

Suppose it is proposed to drive a tunnel with, say, a 5-per cent. upgrade from some point, T , Fig. 4, to the vein. Where will it hit the vein, how long will it be, and what will be its bearings?

Find the strike and side-view. Project the point T to T_v . Draw a line, $T_v M$, parallel to the horizontal plane, and $T_v N$,

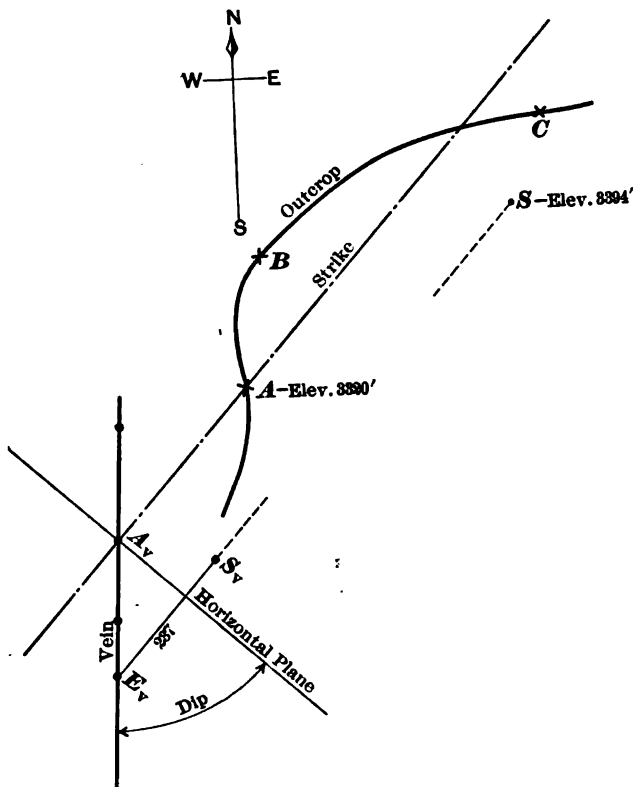


FIG. 3.

making an angle with $T_v M$ corresponding to the grade. $T_v F_v$ is, to scale, the length required. In the plan-view it is obvious that the tunnel will appear at right angles to the strike, which gives at once the bearing-angle. Project F_v up to meet this line, as at F , and we have the plan-view of the point of intersection of the tunnel and the vein. The elevation of F may be obtained by trigonometry, or more simply still by

scaling the difference in level between F_v and the horizontal plane through A_v .

V. LOCATION OF A TUNNEL.

Let A , Fig. 5, be the mouth of an inclined shaft and 1, 2, and 3 be drifts from it, both shaft and drifts following the vein. B is a vertical prospecting-shaft of a certain depth on an adjoining property. What will be the direction and

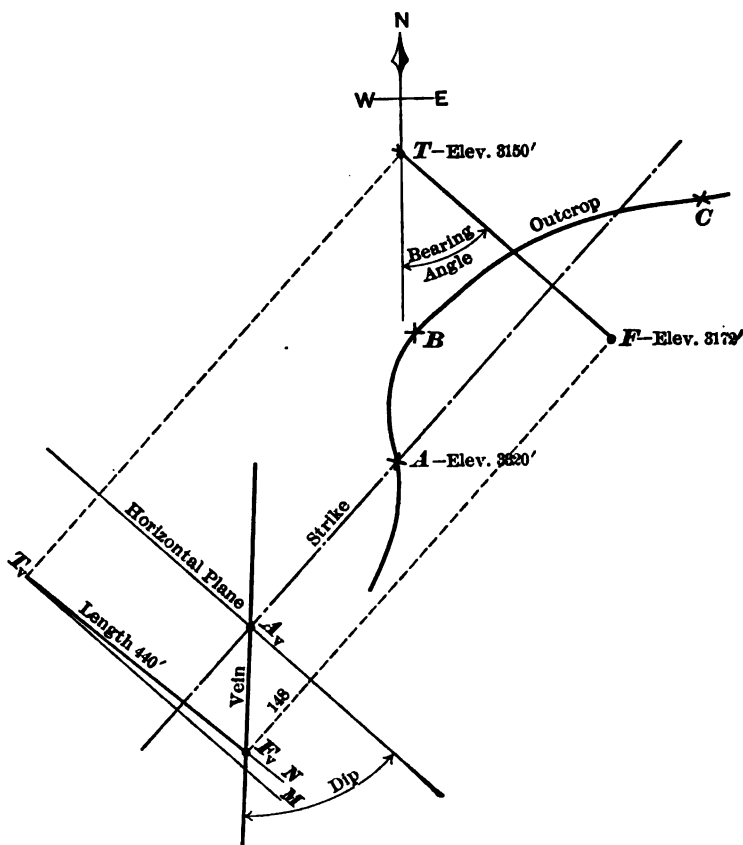


FIG. 4.

length of the shortest drift from the bottom of B to pick up the vein and still keep on the " B " side of the line?

The drifts 1, 2, and 3 are presumably horizontal, and since they lie in the vein they are parallel to the strike. In the end-view they will appear as 1_v , 2_v , 3_v , and will determine the end-view of the vein, the vertical shaft, B , appearing at B_v B'_v . A horizontal line from B'_v will cut the vein at C_v . The line

XY through C_v , parallel to the levels, is the plan-view of the intersection of the vein and a horizontal plane through B_v , and any horizontal drift from B'_v must intersect the vein somewhere along this line. In the plan-view the shortest drift would be $B C'$. But $B C'$ would run out of the property. BC therefore would be the limiting position of the drift to have it entirely on the "B" side of the line.

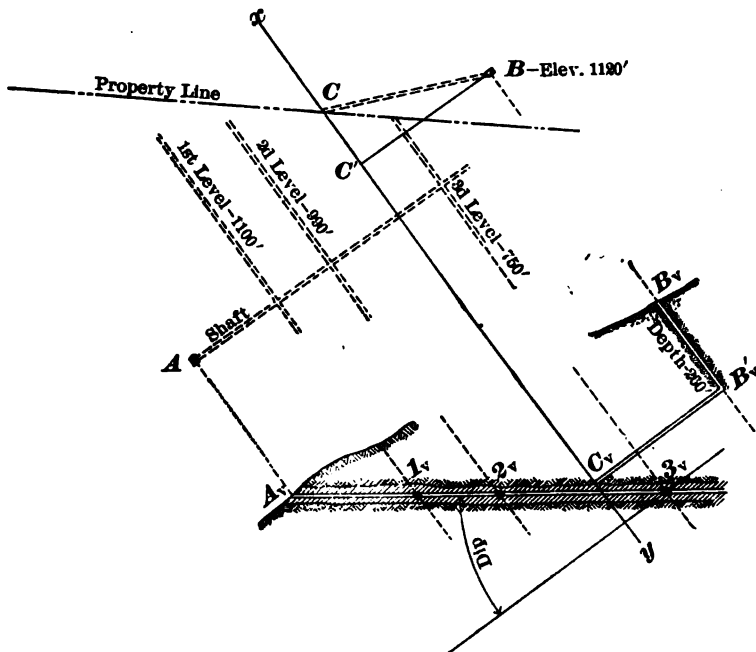


FIG. 5.

VI. TO FIND THE BEARINGS OF A SHOOT.

Suppose we wish to find the bearings of a shoot in the vein ABC of Figs. 1 to 4. Let the shoot appear on the outcrop at B , Fig. 6, and have a pitch of 19° down towards the NE.

A side-view of the point B will show B_v 140 ft. above the level of A . Any line through B with a pitch of 19° from the horizontal must cut the level of A at a distance of mn from the foot of the perpendicular through B_v . All points in the vein on the same level as A lie somewhere along the strike-line. With B as a center and mn as a radius swing the arc XX , cutting the strike-line at some point, S . Connecting B and S , we

have the bearing of the shoot. In the case shown we would expect the shoot to reappear on the outcrop at T . This construction might be used to locate a possible reappearance of a shoot in rough country overgrown with underbrush.

A somewhat similar construction would give the bearing of a drift, lying in an inclined vein and itself inclined at some grade angle, say 10 per cent. Lay off to scale in an end-view a parallel 10 ft. above a horizontal through A_v . Project D_v , the intersection of the parallel with the vein, to intersect an arc, yy , of 100 ft. radius swung from A , as at D . AD is the bearing desired.

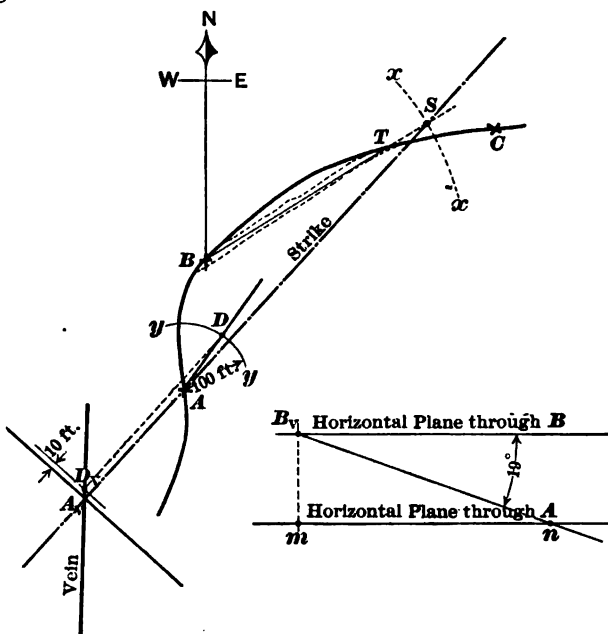


FIG. 6.

VII. TO FIND THE THICKNESS OF A VEIN.

Given the outcrop and dip of the hanging- and foot-wall, how thick is the vein and what is the strike?

Case 1.—Let the side-wall be vertical. Let the outcrops be as shown in the side-view of Fig. 7, their intersections with the ground or other horizontal plane being A_v and B_v . In the plan the side-wall appears as a line. Project A_v and B_v to A and B . Draw any line, yy , cutting the walls at C_v and D_v . Through C_v and D_v draw C_vn and D_vn , making the given

dip angle with the horizontal. The perpendicular distance between these lines is the thickness of the vein. The strike would, of course, be perpendicular to the direction in which the

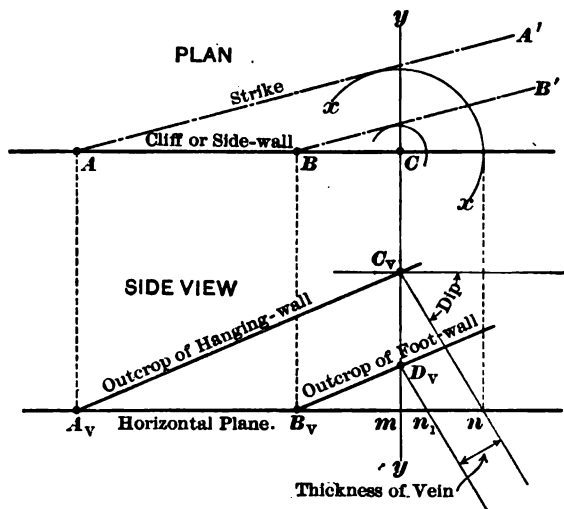


FIG. 7.

dip is measured. A construction giving it more accurately would be as follows: Any plane through C_v having the given

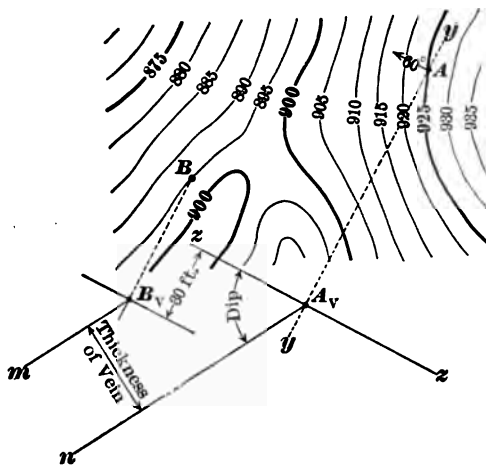


FIG. 7A.

dip angle must cut the horizontal plane at a distance mn from m . With C as a center and mn as a radius swing the arc XX .

The strike-line, AA' , passes through A tangent to XX . BB' is parallel to AA' , or it may be found in the same manner as AA' .

Case 2.—Let the surface be irregular, as, for instance, in Fig. 7A. Let the location and elevation of A and B and the angle and direction of dip be as shown. Draw a projection-line, yy , perpendicular to the direction of dip. Draw any line, zz , perpendicular to yy . Letting A_v be the side-view of A , lay off the dip angle as shown. Lay off B_v on a projecting-line parallel to yy at a distance of 30 ft. below zz . Through B_v draw $B_v m$ parallel to $A_v n$. The perpendicular distance between these lines is the thickness of the vein.

VIII. TO FIND THE LIMITS OF AN ORE-DUMP.

Given the location of a shaft or tunnel, A , Fig. 8, on a certain contour-level as shown, to find the outer limits of a dump formed by filling in on a level with A for a certain radius, say 200 ft.

With A as a center and $AD = 200$ ft. swing an arc, BC , cutting the contour-level of A at B and C . The area between this arc and the contour through A is, of course, the top of the dump. Between B and C the side of the dump will extend down hill a varying distance, depending on the angle of rest of the material and the contour of the surface. Draw an auxiliary view showing a vertical section of the face of the dump. The sloping side appears as the indefinite line, $D_v E_v$, at an angle equal to that at which the material "hangs up," say 40° . Draw a series of levels, aa' , bb' , etc., corresponding to the contour-lines of the map, and to the same scale.

The side of the dump is a portion of a cone, with a vertical line through A as its axis. The top of the dump and the various levels, being parallel planes, cut the cone in a series of circles concentric with the axis. All points on the surface of the ground at an elevation of 980 ft. lie on the 980-ft. contour-line, and all points on the face of the dump at 980 ft. elevation lie on an arc concentric with BC , and having a radius aa' greater than that of the top. Wherever this arc meets the 980-ft. contour, as at 1, 1, there is a point on both the face of the dump and the surface of the ground. The remaining points, as 2, 2, etc., may be located by swinging the arcs from A or by measuring the increase in the radius, as bb' , etc., out from

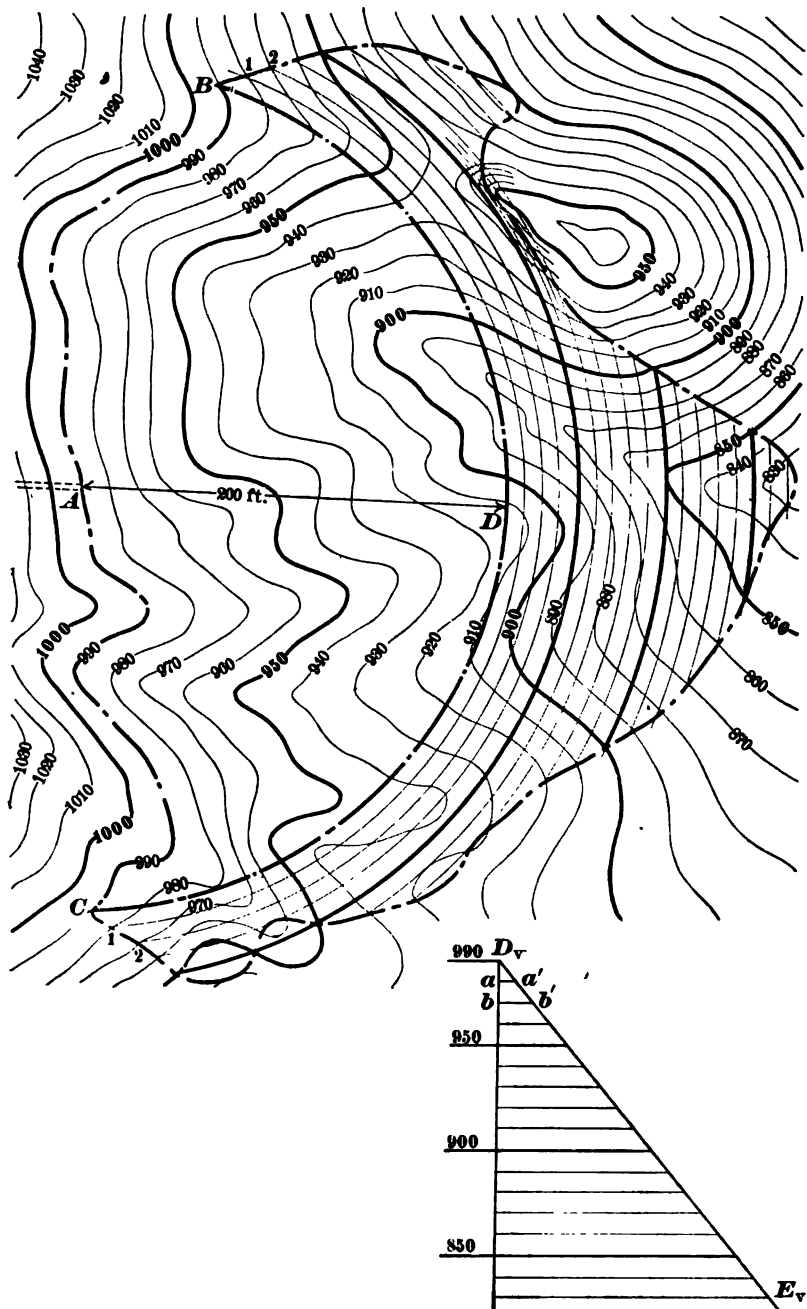


FIG. 8.

the arc BC , to cut the proper contour-line. Connecting the series of points so located, we have the completed outline of the dump.

There may be places where the edge does not cross a contour for some distance. Any uncertainty as to its location may be cleared up by interpolating on the ground and on the face of the dump, as shown on the shoulder of the knoll.

With the limits located and the surface-contours on the face drawn, calculation of the tonnage becomes a mere matter of mensuration. The area of the dump at each level is readily obtained from the contours with a planimeter. Each area will be bounded by a circular arc along the face of the dump and the corresponding irregular contour-line where the dump is in contact with the ground. The volume of each layer may be found by the end-area method or by the prismoidal formula.

IX. ORE-DUMP ON A PROPERTY-LINE.

In practice the problem might easily occur in the reverse form. Given a point, A , Fig. 9, from which it is desired to fill, and a property-line, XXX . How much tonnage-capacity is there available in filling out to the line and extending, say, 200 ft., as before, wherever the property-line is not encountered? In the previous case the upper edge of the dump was regular and the outer one irregular. In this, the limits of a portion of the outer edge are set by the property-line, and the upper edge will, in consequence, be irregular.

As before, we have the crest of the dump starting out from B and C , Fig. 9, the two points on the contour through A at the given limiting distance of 200 ft. For a short distance the crest will be circular, with its center at A , and the outer edge will be found as before. It is evident, however, that the crest cannot swing out far before the property-line is encountered. To determine the side of the dump where it is affected by the side-line we may proceed as follows: Draw an auxiliary side-view. The level of the top, 990 ft., appears as shown, also the side of the dump and the parallels corresponding to the contour-levels of the map. For any points on the property-line, such as a and a' , which are on the 890-ft. level, it is evident that a vertical projection of the crest cannot come within the distance mn of a or a' without having the dump over-run the

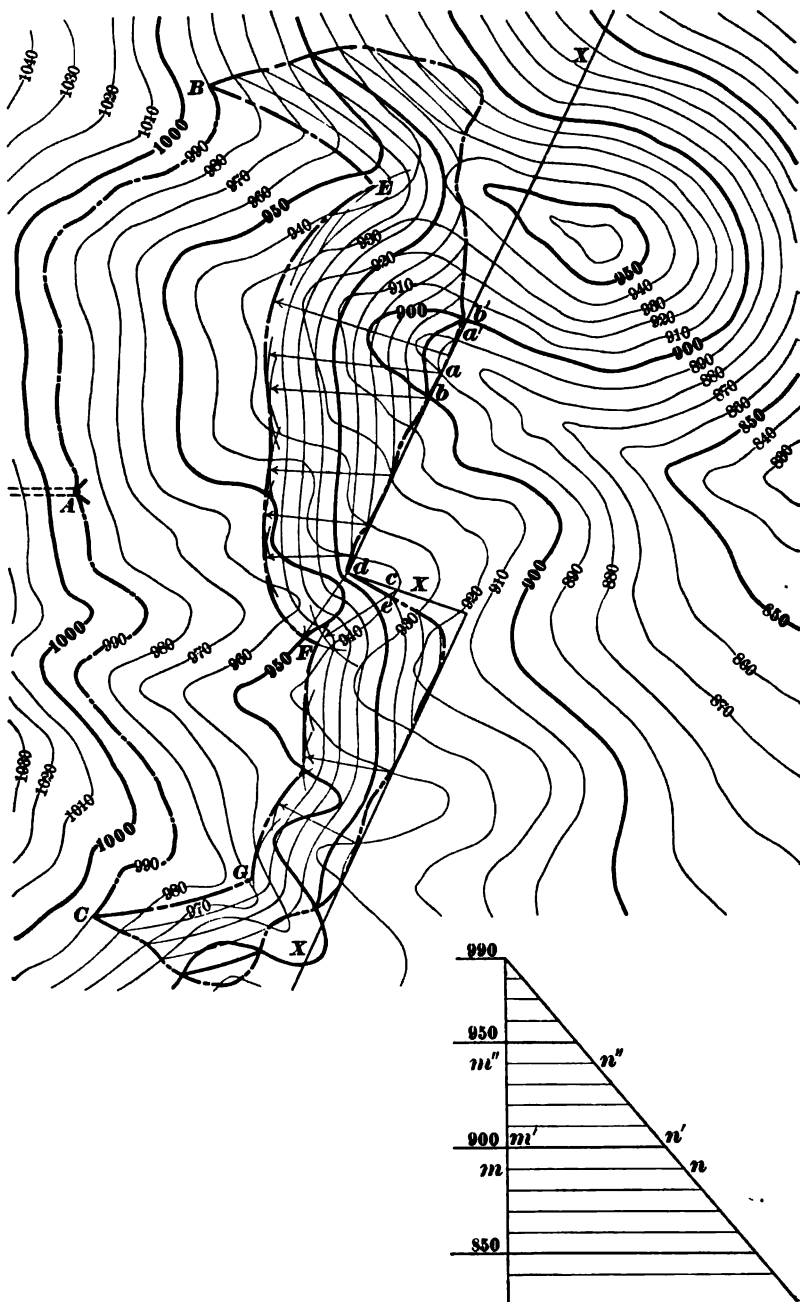


FIG. 9.

side-line. From a and a' , then, swing arcs with mn as a radius. These arcs limit the position of the crest so far as a and a' are concerned. Similarly, for b and b' on the 900-ft. level, arcs swung with $m'n'$ as a radius locate the crest so far as b and b' are concerned. Continuing this process for the intersection of each contour-line and the property-line, we obtain a series of arcs. The innermost arc, or the one towards the uphill side, limits the crest. Drawing a fair line tangent to the inside arcs, we have the crest EFG . An arc not used, such as that from c , indicates that as far as c is concerned the crest might come out to that arc; but the position of that from d , further in, shows that before the material could be filled out to the outer arc it would be over-running at d .

While the line EFG is the farthest limit to which the crest can be carried, it does not follow that the foot of the dump will run out to the property-line at all points. For instance, with the material falling away at an equal angle on all sides, it is evident that F cannot be pushed out far enough to cover the extreme corner without over-running on both sides. A portion of the corner and also any high points, such as those opposite E and G , will remain uncovered. The outline of the base is obtained, as in Fig. 8, by measuring out a distance from the crest equal to that from the vertical in the auxiliary view to the intersection of the sloping side of the given level. Thus, to locate the point e on the 940-ft. contour, cut that contour with an arc swung from F with a radius equal to $m'n''$, etc.

The contour-levels on the side of the dump corresponding to those of the ground will be a series of equidistant lines, the distance between them being equal to the difference between the successive lines $m'n'$, mn , etc., in the auxiliary figure. Wherever the dump-contour and the ground-contour for the same level intersect there is a point on the outer edge or foot of the dump.

X. LOCATION OF RIDGE FOR MAXIMUM CAPACITY.

If it is desired to store a maximum tonnage on a given space the ore must rise from the boundary-line on all sides at the angle of rest of the material. If the ground is level the sides will meet in a point for a square or round area, in a straight horizontal ridge for a rectangular area, and in a straight, in-

clined ridge for an area bounded by non-parallel straight sides. When, however, the ground is broken and irregular, as is generally the case, the sloping sides will no longer be plane surfaces, and will meet in a sloping and irregular crest. It is an advantage to locate this crest in advance, for it is only when the material is deposited along this line that the maximum storage-capacity of the ground is utilized. This crest, then, would indicate the proper location for a dumping-trestle, for material can be filled in along this line until it begins to over-run on both sides at the same time.

Let it be desired to cover the tract shown in Fig. 10, from some point, such as F , on the upper side. Locate F and the course of a dumping-trestle from which the entire tract may be filled in. Use the auxiliary side-view as before and work in from the boundary-lines, the first radii being mn , as at A , B , C , the second $m'n'$, etc. Here every fifth line is used, and the intermediate ones are filled in only along the crest where they are needed. The construction used will be clear to one who has followed the previous two problems. A contour on the dump, starting from C , would pass B at a distance of mn away, and would pass A at a distance of $m'n'$ away, etc. The dump-contours located from each side will be found to intersect along a broken line, FHG , which is the crest. This line is the theoretical course for a trestle and may be adhered to as closely as is deemed desirable. A slight spur would have to be run to the left from a little below H as far as I to fill in the left-hand corner completely, but the capacity gained would hardly justify the expense.

XI. TO PLOT THE OUTCROP OF A VEIN, WHICH MAY BE CONSIDERED AS A PLANE SURFACE.

Descriptive geometry methods may be used to determine the probable outcrop of a vein. First, let the vein be free from faults and foldings, and the strike and dip be known for some definite position, as A in Fig. 11. Draw an end-view looking up the strike-line. For convenience, let this end-view be drawn with the line XX through A perpendicular to the strike as the horizontal plane through A . Let the series of lines parallel to XX be the end-views of the horizontal planes corresponding to the contour-lines of the map. If a number of

line aa' and the 700-ft. contour give points on the outcrop. By locating these intersections for each level and connecting them up we have the outcrop. This method can be used only for comparatively small areas where the vein may be considered as a plane surface. When the vein is faulted to any great extent the treatment becomes complicated, so much so as to preclude its consideration in this paper. When the vein is continuous but folded, as, for instance, a coal-seam, a method of

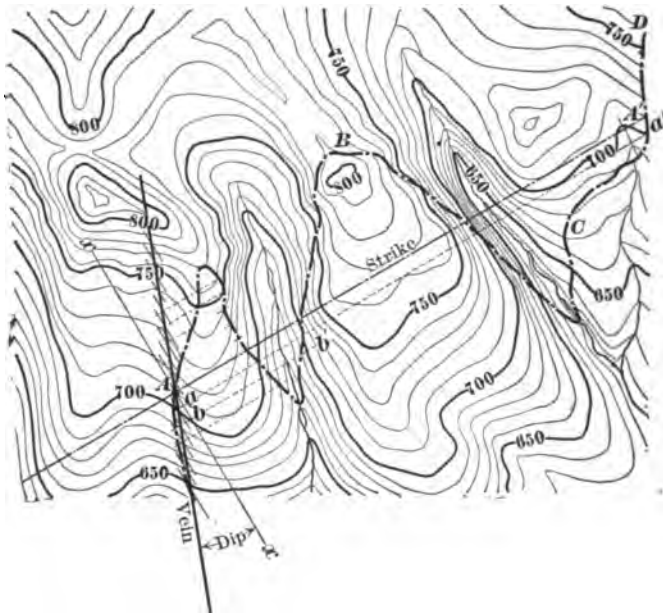


FIG. 11.

determining the outcrop may be used, which is illustrated in Figs. 12 to 12B.

XII. TO DETERMINE THE OUTCROP OF A FOLDED VEIN OR SEAM.

Let Fig. 12 be a contour-map of an area on which an irregular outcrop has been partly located, as, for instance, at the stations marked with an X . At various other points, as 6, 9, 11, 19, drill-holes have been sunk and the seam located at the depths noted. The form of the folded seam may be determined if we can establish its contour-lines corresponding to those on the surface, and where these seam-contours intersect

those of the surface of equal elevation we have points on the outcrop.

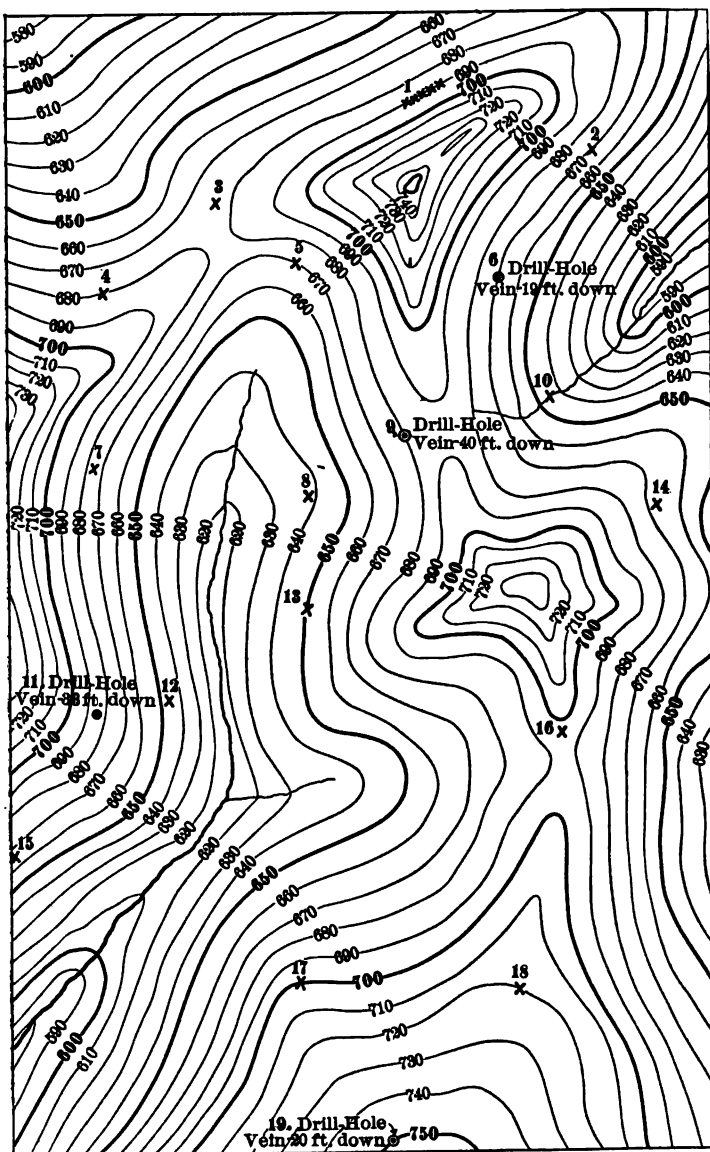


FIG. 12.

. For the sake of clearness, we will gather all the information available into a separate illustration, Fig. 12A. This gives us stations 1 to 19, with the elevations of the surface of the seam

for each, as noted. A general inspection shows that there is a syncline near the middle of the tract, the depression running

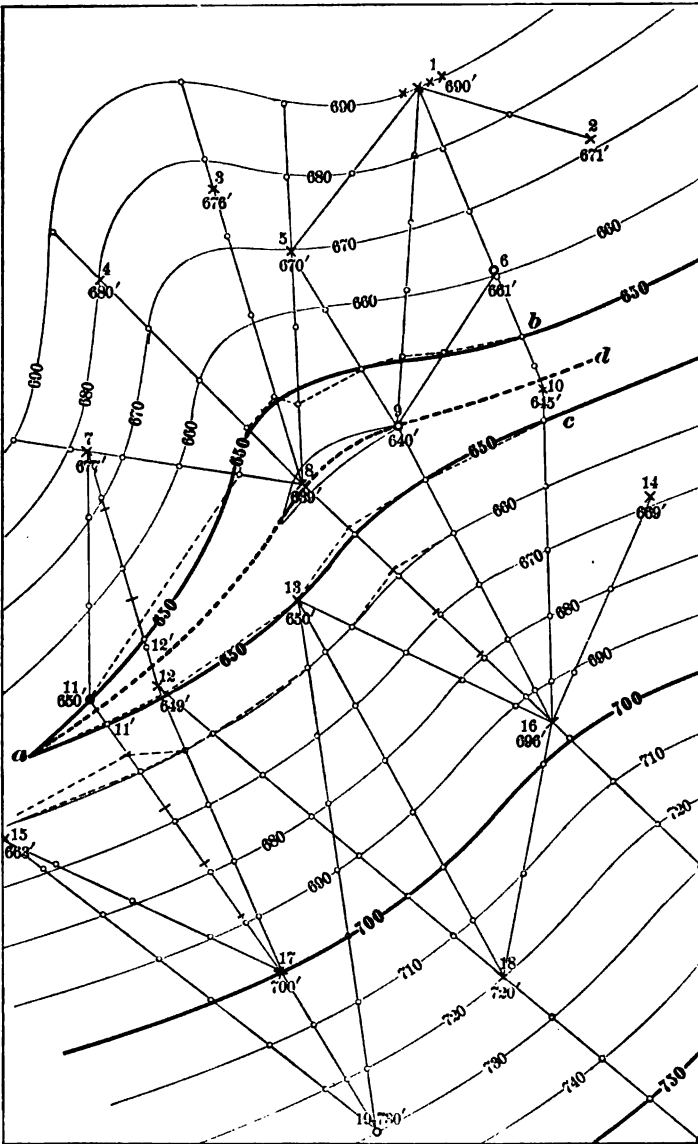


FIG. 12A.

NE-SW., since stations 8, 9, 10, 11, 12, 13 are all at nearly the same level. Assuming, for a start, that the dip from the

higher points, as 16, 17, 18, etc., towards the depression is substantially constant, lines may be drawn connecting the stations,

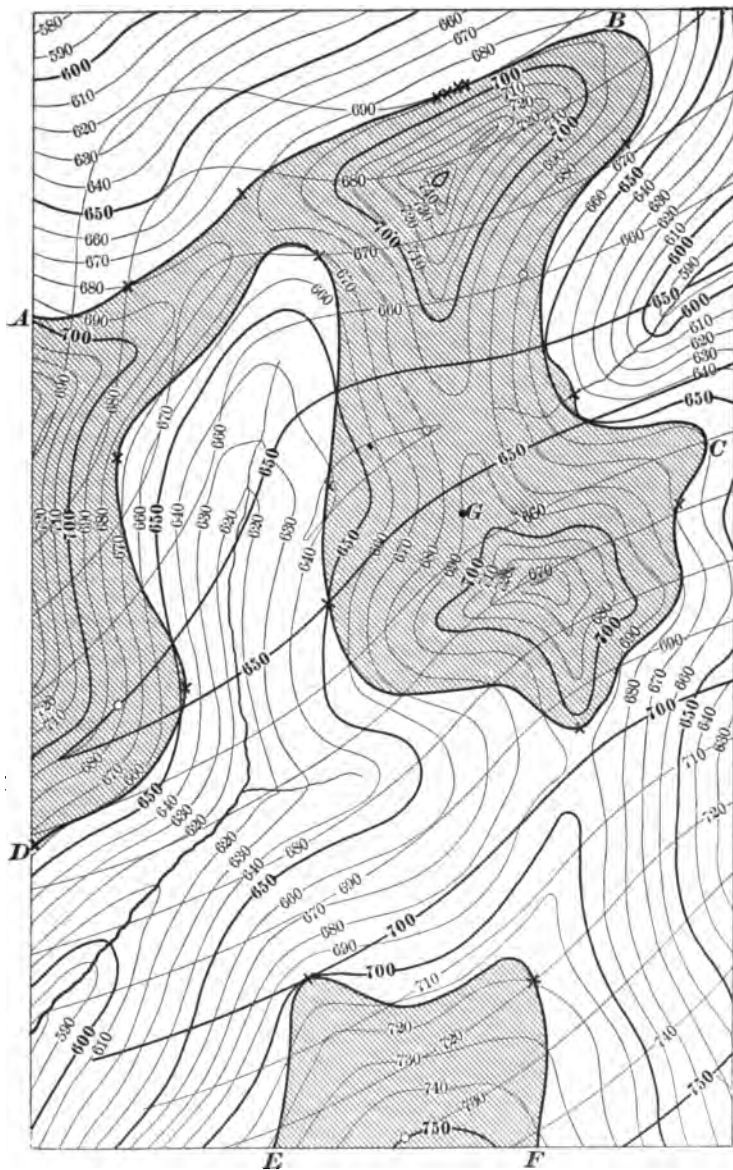


FIG. 12B.

and the elevations at the contour intervals may be interpolated, as on lines 13-16 and 13-18. Where necessary the levels may

be extrapolated, as on the extensions of lines 8-16 and 12-18, but points so located are, of course, not so reliable as the interpolations. They aid, however, in obtaining the general direction of the contours, and as the seam has been eroded at these points great accuracy is not needed.

In this way a series of points of equal elevation are obtained for both sides of the depression. The auxiliary lines, such as 12-18 and 9-16, which are substantially perpendicular to the depression, will be steeper, cross more contours, and give more reliable interpolations than lines more nearly parallel. In interpolating with these lines care should be used that they connect stations on the same side of the depression, as, for instance, 11-17. Station 12 is probably on the same side as 17, but 11 may be, and in fact is, on the other side. This may be determined as follows: The points on the 650- and 660-ft. levels line up well except those marked with a cross-bar on lines 11-17 and 7-12. Rejecting these two sets and connecting the others, we have the broken lines *ab* and *ac*, which give the general location of two 650-ft. contours. Assuming that the trough lies midway between these lines, we obtain the dotted line *ad* as its location. If now we take a new point, 11', on the opposite side of *ad* and at the same distance from it, and interpolate the line 11'-17, we obtain points agreeing well with the others. In like manner, a new set of elevations may be obtained for the lines 7-12, 8-16, and 6-10.

Connecting the various points of equal elevation by curves, we obtain seam-contours, as shown in Fig. 12A. If these seam-contours of Fig. 12A be superimposed on the surface-contours of Fig. 12, we will have a series of points where contours of equal elevation intersect, which will determine the irregular outcrops, *ABCD* and *EF* of Fig. 12B. The shaded portions indicate the areas under which the seam lies. Elsewhere it has weathered away. The probable depth of the seam at any point may be obtained by subtracting the elevation of the seam from that of the surface, as indicated by the respective contours for that point. For instance, at *G* the depth is 690 ft. less 655 ft., or 35 feet.

The value of this contour-method, where the outcrop is overgrown or obscured by soil, is obvious. An excellent example of its application will be found in the Masontown Folio of the

U. S. Geological Survey, where structure-contours have been drawn on the upper surface of the Pittsburg coal-seam, showing its elevation above sea-level. Over large portions of this area the coal has been eroded. Where observations were obtainable a stratum was observed to maintain a substantially constant interval below. This lower stratum was but little eroded, and was used to obtain the theoretical position of the eroded portion of the coal-seam. A number of hills, high enough to pierce the seam thus located, were found to contain portions where its presence would not otherwise have been suspected. This indirect method of using parallel strata was also utilized where the seam lay too deep for observation direct, in this case the stratum being above the seam.

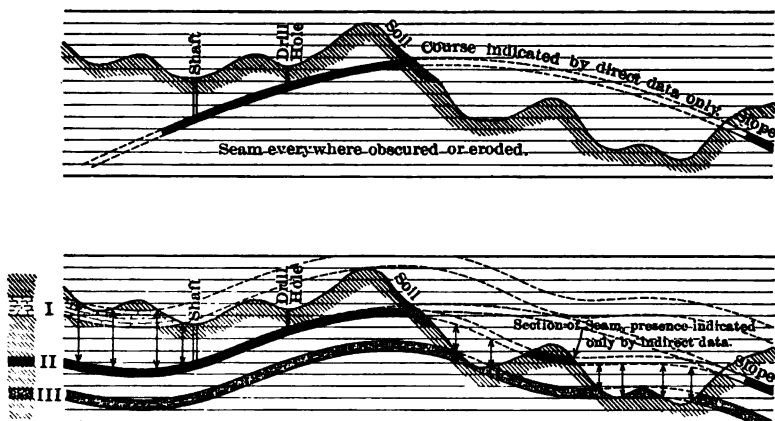


FIG. 13.

Fig. 13 illustrates how parallel strata may be used to corroborate and supplement direct data. This use of parallel strata has been described by M. R. Campbell¹.

The direct data of the upper section, Fig. 13, give only three points on the seam, which is everywhere obscured or eroded. If the intervals between I. and II. and II. and III. in the columnar section be established, and if I. and III. be located at various outcrops, as shown in the lower section, then the intervals may be set off from these outcroppings, and will greatly increase our information on the surface to be contoured.

¹ *Trans.*, xxvi., 298 (1896).

I wish to acknowledge my indebtedness to Prof. John D. Irving, who was engaged on the work of the Masontown quadrangle, and who suggested this structural contour-method as one of the useful applications of descriptive geometry to mining-work.

Professional Ethics.

BY VICTOR G. HILLS, DENVER, COLO.

(Pittsburg Meeting, March, 1910.)

THIS paper comprises suggestions on certain points rather than a complete survey of the whole subject. In other words, it is a contribution to the general discussion invited by John Hays Hammond in his paper, presented as a Presidential address at the Chattanooga meeting of the Institute, in October, 1908.¹

Mr. Hammond says, in conclusion :

“ . . . I am not offering a code, or even an official and representative declaration of principles. My remarks are intended, and will, I hope, be accepted, simply as a contribution to that discussion of their theme in which every engineer of experience may participate.”

Such a discussion has been conducted in technical journals, as well as in contributions to the *Transactions* of the Institute; and, in the remarks here offered, I shall have occasion to refer the reader to what I have thus published elsewhere, for more extended statements of my views.

What Mr. Hammond says about loyalty to employers, the double capacity of the engineer as an employer, the expert witness, commissions on machinery, the statement that most swindling is done by laymen and not by engineers, duty to the investing public, and the engagement of local engineers as colleagues, it is a pleasure to indorse. Under the head of the expert witness, Mr. Hammond refers to the address of Dr. R. W. Raymond on Professional Ethics in the *Proceedings of the American Institute of Electrical Engineers* for November, 1906. This paper contains so much else that is relevant to this discussion that it is a temptation to make extensive quotations from it; but I will refrain from doing so, hoping that the paper may be reprinted by the Institute.

¹ *Bi-Monthly Bulletin*, No. 24, November, 1908, p. 1171, and *Trans.*, xxxix., 620.

Mr. Hammond's "expert's Golden Rule"—"Tell unto others, now, whatsoever you would not have them tell on you (with unjust misunderstanding and scandalous comment) hereafter," is magnificent. Dr. Raymond puts the same idea in the epigrammatical form: "Do not do what you cannot tell." Both of these might be hung, as illuminated mottos, on the wall of an engineer's office.

Charles Catlett,² in his paper, Professional Examination of Undeveloped Mineral Properties, says much that falls appropriately under this head. His paper, both in what it declares and in what may be read between the lines, has a sound and elevated tone of combined professional honor and keen insight, which the active, thorough-bred engineer will not fail to note.

"BLUE-BOOKS," OR OFFICIAL STANDARDS FOR ENGINEERS.

It has often been urged that engineers, like some other professional men, should have an official recognition of their ability and standing. Advocates of this idea would have a State license, or some plan by which there would be a legal recognition of ability, as there is with the legal and medical professions, the object being to protect the public. Exclusive societies sometimes go further and attempt to make their "blue-book" a guarantee of standing and character as well as of ability, and thus to protect both the public and their own members. This is, perhaps, beautiful in theory, but, for the most part, a failure in practice. The unscrupulous and indolent will develop the greatest energy of their lives in getting in, and then depend on official prestige to carry them. Let no one imagine that they will not get in. Attempts to keep them out are futile. Examinations avail but little, even in the line of ability; diplomas do not answer the purpose; "responsible charge of work," or other similar specifications, often admit a mediocre young man, whose rich uncle has secured him a salaried position ahead of a far more worthy independent professional; recommendations and vouchers by those already inside, which should be the most effectual of all safeguards, are not availing; influence, social, political, or financial, secures indorsement with remarkably little trouble. Friends and rela-

² *Bulletin No. 27, March, 1909, p. 327.*

tives would rather get a weakling into some berth than to furnish him with employment themselves. An exclusive society may succeed in keeping its ranks up to a somewhat ideal standard while the organization is new; but, with increasing membership, divergent ideas and interests are bound to develop friendly cliques, which will either admit to membership those who are unworthy or exclude those who are worthy. Balloting by mail on unknown candidates is unsatisfactory. The ballot is thoroughly effective only with a local society, and even there a weakness is developed as the association increases in membership. This is demonstrated in the fact that the long-lived successful fraternities have numerous organizations of the same order in the same city. Among the older professional organizations, occasionally a bar-association, for instance, rejects an applicant; but, through the activity of influential friends, the candidate gets there next time. When a person is once in, it is seldom that sufficient evidence and energy can be developed to put him out. The medical profession is, probably, the most thoroughly and effectively organized of all. Its members are the most courteous to each other, and the organization is usually able to influence legislation in matters concerning its members; yet its best members will frankly admit that there are unworthy individuals among them.

Professional "blue-books" and "Who's who?" lists have hitherto failed in doing the very thing which they propose. A few of the utterly incompetent may be excluded by legal license-systems or by exclusive societies; but the artificial prestige given to those just able to work themselves in, opens another danger, by throwing the public off its guard; and this danger may be even greater than that of a free field, with the employer on the lookout.

PROFESSIONAL TIMIDITY.

I once heard an engineer avow that he always took from 20 to 25 per cent. from his estimates of value, so as to be on the safe side. In his selfish caution he entirely overlooked the rights of his employer, who might be thereby robbed of a good bargain, and of the examination-fee also. This reprehensible practice, or something like it, is so common that I have often felt constrained to say to a client that the results which I had submitted were exactly what I had calculated, and were as likely

to be in error one way as the other. In some cases I have added a recommendation that he allow a certain percentage for safety in making his investment. In other cases I have said, "Your experience in investments of this character will enable you to apply your own safety-allowance without any recommendation from me." It is not an engineer's privilege to assume a safety-factor for a client without the client's knowledge.

Another form of cowardice appears in withholding the details which would enable another engineer, or perhaps an accountant, to verify the results given. It is not a sufficient excuse that the employer will not read the details if given to him. He may not wish to read them at the time; but he may find occasion to refer to them in subsequent operations. His money has paid for them; and the record he receives should include them. Sometimes the object of withholding data seems to be to make the author indispensable for future operations. It is doubtful whether this is often successful. Quite as often it has the opposite result—it acts as a professional boomerang and brands him as incompetent or unfaithful.

COURT-WORK.

More has been said and written on this subject than on any other branch of engineering work. The fierce criticism which has been brought upon the profession by the acts of some of its members in bitterly-fought law-suits has made this class of work better known to the general public. Some of this criticism has been just and some most unjust. Since there are always opposing attorneys with ability to make effective use of unjust and insinuating language, the weakest features of expert court-work have been thoroughly paraded.

Indorsing all that has been said by Mr. Hammond and Dr. Raymond, I have little to add. The idea that experts should be appointed by the court, I am inclined to think is more fanciful than practical. Since the court would have in advance no knowledge of conditions which would guide it in the selection of the proper expert for the particular case, a certain bent of mind or the prejudice of an individual might decide a case unjustly.

Court-work is unpleasant to most professional men. I recall

only two engineers whom I have heard declare that they like it; one because his bellicose nature enjoys the conflict with the cross-examining attorney, and the other on account of the mental discipline experienced by him under such examination.

VENDORS' REPORTS.

I agree with Mr. Hammond that a report for a seller should not be condemned as unprofessional. Indeed, he goes perhaps too far. If proper precautions are used, I hardly see why even the young engineer need avoid this work. When such a report is made in the proper form, its character as a seller's description of his property is apparent, and it frankly challenges verification by any other engineer who may be selected by the purchaser. The author protects the public in protecting himself. A mistake will reflect on his judgment, and a too-enthusiastic description will react injuriously on his business, but not on his honor. The fact that a report is made for the owner should show in the text and over the signature. If the engineer is to be compensated for his work by a commission, he makes himself a partner in the enterprise, and this must also be shown in the report. Then his statements will be weighed accordingly. The small investor will buy with his eyes open, and the heavy investor will, in any event, employ his own engineer.

PROFESSIONAL CONFIDENCE.

One of the vital principles of professional ethics is the inviolability of confidential information. This is generally recognized by engineers and by all professions, but there cannot be too emphatic a declaration of it. What Mr. Catlett says on this point is good and thorough, and I fully indorse it. But complete confidence on both sides is essential to a satisfactory result. The client who, keeping his plans to himself, engages an engineer simply to give him information, is really not a client, but only an employer, and does not realize the enormous handicap which he is placing upon his employee. The time and labor involved in making a report may be doubled or quadrupled for lack of knowledge of the exact purpose for which it is to be made. The engineer, for fear of overlooking some point which might prove important, does unnecessary field-work, and so on through his whole engagement, wasting am-

munition by firing in the dark. Even then he is likely to miss something which would have been desirable. With full mutual confidence, the work is done more quickly, economically, and satisfactorily. By explaining this, I have usually induced my client to state his purpose more fully. In my younger days, I used to wish that he would stay away from the work until it was done; now I rather encourage him to accompany me. However uncommunicative he may intend to be, he will be likely to reveal in conversation more than he would have put in writing; and thus I am enabled to serve him more effectively.

STOCK SPECULATION.

Under this head I include the buying and selling of property interests, whether in the form of stock or not.

J. R. Finlay says :³ "As to an engineer investing in stocks or speculating in them, it seems to me that his activities in that direction should be no more limited than those of any other man of common sense." I have already expressed elsewhere⁴ my dissent from this proposition, so far as it applies to the buying and selling by an engineer of the stock of a company with which he is associated professionally. As I then said : "The limit is that professional engagement and pecuniary personal speculation shall not be tolerated together in connection with the same enterprise;" and I added that, apart from such professional connection, the engineer has an unquestionable right to speculate in stocks, though I questioned the policy of his doing so. For a more extended statement of my views on the subject, I would refer to the article cited above.

CONTINGENT FEES.

Contingent fees furnish the chief debatable ground in the discussion of professional ethics. If an engineer should make a report for a seller, for which he is to receive a greater amount in case the report accomplishes its object, or for which the compensation is a commission on the sale, the performance is one thing if the relations are kept secret, and quite another thing if the relations receive full and unreserved publicity, by which the transaction is at once transferred to the category of "vendor's

³ *Mining and Scientific Press*, vol. xcvi., No. 2, p. 80 (Jan. 9, 1909).

⁴ *Idem*, vol. xcvi., No. 9, p. 312 (Feb. 27, 1909).

reports," and would be practically so considered by any buyer. The author of such a report, having announced himself a partner of the vendor, has satisfied the requirements of professional honor, and henceforth, in that particular transaction, is amenable only to the rules of common sense, honesty, and policy. A vendor's report, made for a fixed compensation, with suppression of the fact that it is made to promote a sale, would be reprehensible, but it would not come under the head of "contingent fees."

Mr. Hammond, in justifying contingent fees, apparently confined his opinion to vendor's reports, publicly acknowledged as such, or those which are virtual partnership arrangements. So far his declarations are sound and safe; but his proposition that a legitimate contingent fee should depend upon "the subsequent success of the enterprise" seems to me impracticable. How long shall we wait to satisfy this condition? and, in case of failure, how settle the question of the responsibility?

In this connection, however, I would add that a contract for the receipt of a percentage of the proceeds of a proposed metallurgical improvement is, in my judgment, an excellent and unobjectionable professional partnership.

Removing from the category of "contingent fees" the cases which are virtually partnerships, the problem is simplified, and there remain only the cases in which something is received as remuneration which may depend for its value, wholly or partly, upon the color of the engineer's report; in which personal gain might be, or even might be conceived to be, a temptation to say a thing or to leave a thing unsaid. In such instances I contend that a contingent fee is unprofessional and culpable; that an engineer has no more right to accept one than a judge has to sit on a case in which he is interested. A judge, however high and unimpeachable his position, will decline to sit where a relative or near friend is interested. The engineer's position is quite as delicate.

If a "contingent fee" were put in such a homely form that it could not possibly escape being branded as a bribe, even our "commercial" engineers would regard it with scorn. And if we could class all cases as either bribes or partnerships, the question would be settled; however, the painful fact confronts

us that a goodly number are found defending contingent fees by sophistry and labored illustrations.

FORMS AND CONTENTS OF REPORTS.

The days are long past when elaborate treatises on history, geology, and topography were used for the body of an engineer's report; but the swing of the pendulum seems to have brought some to the extreme of presenting seductively simple and summary financial statements only. Mr. Finlay has given⁵ typical report-forms illustrating the extremes, thus:

Mr. Smith, engineer: ". . . I have examined Mr. Jones' farm of 160 acres in Washington county, Pennsylvania. I find such and such openings and such and such drill-holes. I estimate that the coal seam on the farm will average 5 ft. 9½ in. thick, and that the average analysis of the coal is 60% fixed carbon and 10% ash, etc."

Mr. Brown (another engineer): ". . . Jones' farm of 160 acres can be depended on, in my judgment, to produce a million tons of coal, which can be mined for \$1 per ton and can be sold for \$1.25 per ton. It can be worked out in 10 years, at a total profit of \$250,000. I figure its present value at \$125,000."

Neither of these reports is satisfactory. The "Smith" style is antiquated; the employer wants the figures in money-value, or else he would not employ an engineer at all; but the "Brown" report is equally bad, professionally, and more dangerous; because the employer could take the Smith report and, perhaps with some assistance, arrive at a solution of the commercial problem. A proper report should contain the items given by both Smith and Brown, and more. There should be a map showing the location of every opening and drill-hole and the thickness of the coal at each. In short, the report should contain all the information employed in reaching the author's conclusion, and paid for with the employer's money. Statements of quantities and values are usually not enough; they should be reinforced by opinions, based on experience and judgment, including such matters as probable changes in transportation and market-supply, which are likely to make the whole difference between profit and loss.

A report consisting almost wholly of opinions is another weak form. The conscientious engineer will not assume omnipotent judgment and exclude the employer from his confidence, by

⁵ *Mining and Scientific Press*, vol. xcvi., No. 2, p. 80 (Jan. 9, 1909).

withholding the data and the reasoning which underlie his conclusions. Moreover, it is his duty to give such details as will enable a subsequent expert investigator to check and weigh the opinions he has expressed.

While pedantic exhibitions of scientific knowledge are to be condemned, the subjects of geology, mineralogy, and the like should not always be ignored. Instead of omitting all mention of geology, I think it usually best to give something, probably a plain condensed statement, in a single paragraph. The mineralogy may be dispensed with, or it may be disposed of in a few words, or it may be the main feature of the report—and so on with other items, according to circumstances.

To avoid making a report too cumbrous and dull, I like the plan of putting a table of contents, together with an abstract and summary, at the beginning, instead of a recapitulation at the end. Such details as assay-lists, detailed plats, tabulated cost-statements of various kinds, etc., can be put in supplements or appendices for convenient reference. The preliminary abstract, probably condensed to a single page, with the explanation that it contains the essence of the entire report, and that the remainder is submitted for the sake of completeness and possible future reference, will make the report satisfactory to any reader and under varying conditions.

It should not be understood that I advocate elaborate detailed reports in all cases. One of the most important and satisfactory reports which I ever made covered about four sheets of note-paper, and was written with a fountain-pen while riding on a railroad train; another had to be made, practically complete, by telegraph. The circumstances vary widely in a mining engineer's experience.

It is hardly necessary to remark that an engineer should be scrupulously careful to keep an exact copy of every report, including the plats as well as the text, as a protection. To prevent the mutilation of a report, I often write, just over the signature, something like this: "Five pages of text, three plats, and two inventory-sheets." It is always possible that a report will turn up at a time and place for which it was not intended. This cannot be avoided. The recipient has the right to publish or sell a report, or to make any use of it which he sees fit, so long as he does not make it misrepresent itself by mutilation or

unfair quotations. A little care in embodying, to some extent, circumstances, conditions, and purposes in the text of the report, will do much to forestall future misrepresentation or misuse of it.

THE DEMAND FOR SUFFICIENT TIME.

There is no section of this subject more worthy of consideration than that of demanding sufficient time to do justice to professional work. The young engineer in particular can study this subject with profit, but the question never vanishes throughout the longest professional career. The engineer is continually approached to make some report, or to act as an expert witness, without sufficient time for preparation. Sometimes, from shrewd motives of economy, the employer comes with the statement that the work must be done by a certain date; sometimes the cunning promoter endeavors to cut the time short in order that the weak points may escape observation; but perhaps more often than otherwise, the employer, through pure ignorance of the time necessary, delays speaking to the engineer until the expiration of an option or the date of a court trial is too near at hand. There are cases where professional aid is sorely needed in like emergencies, and the engineer may respond to the call, and is constrained to do so, particularly if it is for an old client; but such work should be undertaken only by those of experience and fairly well-established reputation, and avoided as an extremely dangerous class of work by the inexperienced. The temptation is great; it is comparatively easy to stay the conscience with the thought that an engineer cannot report on more than he is able to see, or be held responsible beyond the points covered. Nevertheless, right here lie great dangers and many pitfalls. If he cannot do justice to the case he cannot do justice to himself. He must decline employment, to stand by his colors. I can think of no branch of the subject in which professional ethics comes closer to every-day practical application.

COMPLICATIONS AND EMBARRASMENTS.

An engineer is called upon to make an examination and report where he already has much knowledge gained from work on neighboring properties. Perhaps it was this knowledge which led to his selection. He cannot betray the confidence

of his former employers, and he is practically unable to act and judge entirely independent of his previous knowledge. Sometimes permission to use any data will be freely granted by the prior employers; sometimes the work can be done in an entirely independent manner without embarrassment; sometimes the offered employment is a covert attempt to bribe, an attempt to secure some knowledge of a neighbor's property which could not be obtained in any other manner; and, most embarrassing of all, this object may not at first be apparent, or the engagement would have been declined at the outset. Between these extremes there is a field for every possible shade of embarrassment. The situation changes by insensible gradations from cases which would be promptly declined by any self-respecting man to those which could be performed with the most frank and agreeable understanding of all concerned. Here no fixed rule can be established, and common sense and discernment must be the guide to keep on the safe side.

Using the notes and data taken in a case where the question of secrecy is waived, or not involved, and charging for the same in future cases, is an often-discussed question. I can see no difference between notes on paper and those which are impressed on the mind. The older professional man is expected to earn more with accumulated knowledge. The question may be a matter of bargain and understanding with the client.

The right to sell information to another, where the first employer has hopelessly failed to pay his bill, raises a fine point; and this is further complicated if a small advance payment on account has been made. The law and the equity might conflict. A case might depend so much on the particular conditions that no general rule could be made applicable.

Taking advantage of knowledge gained in the employ of one mine to secure a personal interest or a lease in an adjoining property, raises an ethical point. By first imparting the full information to the employer, and giving him the refusal of the same opportunity, the way is cleared. Holding a lease on a property which pays the engineer a fee for consultation may possibly be justified in rare instances, but, even with full knowledge, it is, to say the least, treading on dangerous ground.

An engineer may be employed at two neighboring mines; after a while there comes an unexpected clash of interests,

when he is expected to advise both parties. Then he can do neither more nor less than stand aside and tell the contending parties to employ other experts. And the same idea may be carried out when the engineer's personal interest conflicts with his employer's. Both attorneys and engineers are sometimes caught in such a predicament: it may involve embarrassment, but can always be so handled as to avoid dishonor.

The professional members of the United States Geological Survey are not only forbidden to testify in any mining-litigation during the term of their employment, but are bound not to do so for three years after leaving the service. The reason for this is sound and obvious. In general, the engineer should not serve another client too soon after quitting the employ of a rival. How soon, must depend on circumstances: often he can never honorably do so.

THE LIFE-LONG PROFESSION.

Granting an engineer's right to speculate in stocks, to become a partner in purchases, or to act as a promoter when not in connection with a professional engagement, there still remains the question of good policy, involving all the really fine points of professional ethics.

If we are to follow the profession for life we must forego some of the rights of the commercial engineer. It is a mistaken idea that the employer of professional service looks for one who is himself exhibiting great personal financial prosperity. My observation is that too keen an exhibition of the money-making quality rather begets distrust. The miner or the investing public is more sensitive to professional constancy than some seem to perceive.

Even when considered with reference to pecuniary income, the question should be treated from the stand-point of a business which is to yield a revenue throughout an active life, and not as only a stepping-stone in finance. We do not have to reflect long to recall some engineer whose financial activity readily betrayed the fact that he had taken hold of the profession only as a vaulting-pole, to be quickly dropped when it had served its purpose. The commercial engineer is like a lessee, who sinks a little shaft, without timbering if possible, leaves rubbish in every drift, gouges out by underhand stoping the

first bunch of ore found, and finally leaves the place to cave in. The thoroughbred professional man is like an owner who puts down a well-timbered shaft, of sufficient size and equipment, and does his work in "miner-like manner," that the place may be worked as long as it will yield. Our commercial engineers at least lay themselves open to the suspicion of treating the profession after the manner of the lessee. In discussing the ethics of the situation, I think we should take the stand of the owner and ignore the lessee.

Sampling Anode-Copper, With Special Reference to Silver-Content.

BY WILLIAM WRAITH, ANACONDA, MONT.

(Pittsburg Meeting, March, 1910.)

I. INTRODUCTION.

At the Washoe smelter, Anaconda, Mont., the blister-copper from the converters is transferred, by means of a crane, to a refining-furnace, in which it is brought to proper pitch by means of air and poles. From this furnace the refined copper, containing gold and silver, is poured into cast-iron molds placed on a platform-conveyor, giving an anode 36.75 in. long, 28 in. wide, and $2\frac{1}{8}$ in. thick.

By reason of a disagreement between the smelter and the refinery, in reference to the silver-content of the anodes, it became necessary to investigate the methods of sampling used.

II. SMELTER METHOD OF SAMPLING.

At the smelter the sampling is done by "shotting" into water a small portion of the molten stream of copper as it flows from the furnace, by "batting" the stream with a wooden paddle. The first sample is taken 30 min. after the pouring is started, three other samples being taken at 1-hr. intervals, each sample weighing from 4 to 6 oz. The samples are dried, examined for particles of burnt wood, screened on a 10-mesh screen of No. 8 wire to remove the fines, the oversize then screened on a 4-mesh screen of No. 20 wire to remove the coarse, the undersize of this screen being taken as the sample. The four portions thus obtained are thoroughly mixed and split in half by passing over a 16-slot splitting-device, slots being 0.5 in. wide. One-half of the sample is sent to the laboratory for analysis and one-half kept as a duplicate.

III. REFINERY METHOD OF SAMPLING.

The method used at the refinery and also used in this investigation is the one developed by Dr. Edward Keller, of

Perth Amboy, N. J., in which every fourth anode of a lot is drilled, using a 99-hole template, illustrated in Fig 1, which also shows the shape of the anode. The holes of the template was used in continuous order, one hole to the anode; for example, if in lot No. 890, holes from No. 1 to No. 90 were used, then in lot No. 891, the sampling would commence with hole No. 91.

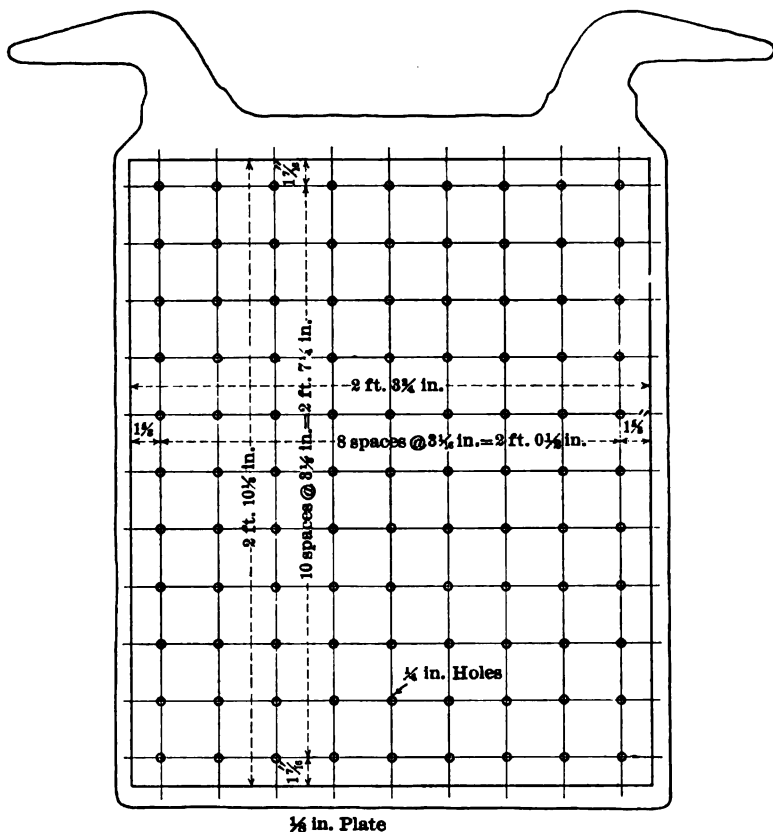


FIG. 1.—DRILLING-TEMPLATE FOR SAMPLING LARGE ANACONDA ANODES, WITH OUTLINE OF ANODE.

The anodes are carefully swept to remove foreign matter, then drilled with a 0.5-in. drill from the bottom side completely through the anode, every portion of the drillings being saved. The drillings from the entire lot are run through a grinder until the sample will pass through a 16-mesh screen. The sample is then thoroughly mixed and quartered, each quarter weighing about 1 lb. The 1-lb. sample is screened over

a 40-mesh screen, weighing the oversize and undersize, thus determining the ratio of coarse to fine, the same ratio being maintained in the assay-ton made up for analysis.

IV. LADLE-SHOT METHOD OF SAMPLING.

Incidentally, another method of sampling was investigated—namely, the taking of a ladleful of copper from the furnace or furnace-stream, and shotting it by pouring over a wooden paddle into water, thus making shot, which was treated in the same manner as the “regular shot sample.”

V. INVESTIGATION OF SMELTER SHOTTING METHOD.

1. To determine the uniformity of the charge during the pour, shot samples were taken each hour of the pour, as follows :

Lot No.	First Hour. Silver-Content. Oz. per Ton.	Second Hour. Silver-Content. Oz. per Ton.	Third Hour. Silver-Content. Oz. per Ton.	Fourth Hour. Silver-Content. Oz. per Ton.
873	73.36	73.41	.....	73.58
1000	73.79	73.79	73.82	73.79
1001	72.93	72.81	72.99	73.06
1002	76.07	75.95	76.19	76.37

2. To determine the possibility of segregation of silver in some portion of the stream as it flowed from the furnace, samples were taken from different parts of the stream. These samples showed :

	Silver-Content. Oz. per Ton.
Front of stream,	72.38
Middle of stream,	72.29
Back of stream,	72.28

3. To determine the possibility of segregation of silver by using a cold wooden paddle, shot samples were taken, using a wooden paddle and a red-hot clay paddle. These samples, on analysis, gave :

Lot No.	Wood Paddle. Silver-Content. Oz. per Ton.	Hot Clay Paddle. Silver-Content. Oz. per Ton.
936	74.50	74.60
950	73.76	73.55

VI. INVESTIGATION OF REFINERY DRILLING METHOD.

To test the uniformity of the anodes, six anodes were selected at equal intervals during the casting of a lot. Each anode was drilled in 99 places by the template; the drillings assayed as follows :

Lot No.	Anode No.	Silver-Content. Oz. per Ton.
956	1	71.36
956	2	71.54
956	3	71.21
956	4	71.41
956	5	71.68
956	6	71.51
Lot No.		
885. Random anode,		73.41
885. Regular sample of lot,		73.76

Two lots of anodes were taken from lot No. 911 for drilling samples. Sample A is the regular drilling sample, obtained by drilling one hole in every fourth anode according to template, and commencing with the first anode cast. Sample B was obtained in the same manner, but starting with the third anode cast.

	Silver-Content. Oz. per Ton.
Sample A,	74.31
Sample B,	74.50

The last anode of another lot, No. 917, drilled with 16 holes, 8 on each diagonal, gave the following results:

	Silver-Content. Oz. per Ton.
Last anode,	74.52
Assay of lot,	74.76

A comparison of the results obtained by the shot-sampling method and by the drillings-sampling method on the same lots is given in Table I.:

TABLE I.—*Results of Shot-Sampling and Drillings-Sampling.*

Lot No.	Shot Sample. Silver-Content.	Drillings Sample. Silver-Content.	Lot No.	Shot Sample. Silver-Content.	Drillings Sample. Silver-Content.
	Oz. per Ton.	Oz. per Ton.		Oz. per Ton.	Oz. per Ton.
950	73.88	73.75	965	72.97	72.91
951	72.60	72.18	966	70.93	70.80
952	71.91	71.58	967	71.79	71.50
953	71.78	71.68	968	72.62	72.42
954	73.76	73.62	969	73.10	73.22
955	71.85	71.31	970	72.53	72.63
956	71.60	71.35	971	71.20	71.09
957	70.08	70.08	972	73.25	73.30
958	70.96	70.90	973	74.53	74.47
959	69.56	69.66	974	74.67	74.67
960	71.33	71.38	975	77.55	77.07
961	71.00	70.98	976	77.96	77.73
962	70.29	70.32	977	76.84	76.84
963	71.09	70.98	978	75.63	75.25
964	71.24	71.10			

The average weight of the lots given in Table I. was 106 tons.

VII. INVESTIGATION OF THE LADLE-SHOT METHOD.

1. In Table II., the ladle samples were taken from the furnace, with hot and cold ladle, at the same time a regular shot sample was taken from the stream flowing out of the furnace. After pouring the shot required, the "skulls" left in the ladle were sampled by drilling.

TABLE II.—*Results of Using Hot Ladle and Cold Ladle.*

Lot No.	Shot Samples.		Furnace Shot Samples.	Skulls.	
	Cold Ladle. Silver-Content. Oz. per Ton.	Hot Ladle. Silver-Content. Oz. per Ton.		Cold Ladle. Silver-Content. Oz. per Ton.	Hot Ladle. Silver-Content. Oz. per Ton.
967	73.83	71.74	71.35		
968	74.54	72.71	72.43		
969	73.28	73.86	73.13		
970	75.85	74.27	72.59	70.57	70.67
971	72.69	73.58	71.16	67.52	67.34
972	74.78	75.71	73.18	71.97	72.09
973	76.79	75.64	74.47	71.07	72.29
974	79.31	75.18	74.78	73.47	72.26
975	78.49	78.65	77.68	76.99	76.93
976	82.71	80.32	78.07	75.19	75.21
977	79.59	78.27	76.96	76.25	76.10
978	77.90	77.15	75.54	74.48	74.18
979	80.03	76.29	75.68	75.08	75.22
781	77.67	79.22	74.80	73.48	74.12
782	75.88	76.71	74.74	74.11	73.02
983	76.02	76.97	74.79	74.19	74.52
784	74.93	75.84	73.76	72.40	71.99
985	76.83	76.05	75.17	74.68	74.48

2. An 8-in. ladle was half filled with copper from the furnace-stream, and three separate shot samples taken from it, at the same time a shot sample was taken from the furnace-stream. The results obtained were:

	Silver-Content. Oz. per Ton.
Sample No. 1,	76.42
Sample No. 2,	78.67
Sample No. 3,	81.02
Skull left in ladle,	72.89
Regular shot sample taken from the furnace-stream,	74.99

3. An 8-in. ladle was entirely filled with copper from the furnace-stream, and four shot samples taken from it at the same time a shot sample was taken from the stream. The results were:

	Silver-Content. Oz. per Ton.
Sample No. 1,	75.85
Sample No. 2,	77.11
Sample No. 3,	78.40
Sample No. 4,	81.44
Skull left in ladle,	73.35
Stream shot sample,	74.99

An 8-in. ladle was half filled and allowed to cool completely. The resultant button was drilled, with the following results:

	Silver-Content. Oz. per Ton.
Top of button,	79.45
Center of button,	75.73
Bottom of button,	68.91

4. In order to see how high a result could be obtained by the ladle-shot method, an 8-in. ladle was filled with copper and allowed to stand until nearly frozen, when the metal remaining molten was shot, with the following result:

	Silver-Content. Oz. per Ton.
Ladle-shot sample,	86.17
Correct shot sample,	73.67

VIII. CONCLUSION.

The conclusions reached were (1) that the shot sample taken from the furnace-stream, and the drillings of every fourth anode according to Dr. Keller's template, will check within practical limits, and give the true silver-content of the copper, and (2) that the ladle-shot method will give high silver results, due to a segregation of silver towards the portion that solidifies last.

I wish to acknowledge the valuable assistance given by Frederick Laist, assistant superintendent, Washoe Smelter; and C. D. Demond, testing engineer, in the carrying-out of the details of this investigation.

Dust-Explosions in Coal-Mines.

BY GEORGE S. RICE, PITTSBURG, PA.

(Pittsburg Meeting, March, 1910.)

THE extremely valuable papers and discussions on coal-dust explosions by Bache,¹ Eavenson,² Shurick,³ Mannakee,⁴ and Raymond⁵ are of unusual interest to me, since it has been my duty to carry on investigations on this and allied subjects for the Technologic Branch of the United States Geological Survey during the past year, and to make a series of coal-dust tests in the explosion-gallery at Pittsburg during a short period when its use could be diverted from the pressing work of testing explosives.

In several of the discussions mentioned, it has been assumed that the Technologic Branch of the Survey was not paying attention to certain phases of the general problem, or to the specific question of temperature and humidity of mine-air in its effect upon the explosibility of coal-dust. This assumption is not correct, since from the time of the establishment of the "Mine-Accident Division," with its subdivisions of explosives, rescue-work, and mine-investigation, the mining engineers of the last-named section have made the subject one of chief consideration. Their general duties, including mine-sampling for government purposes, emergency-calls for rescue-work, and explosion investigations, have prevented undivided attention, but all of them have been supplied with instruments for such determinations, and special report-forms have been in use and a great many observations made in mining-districts to which the mining engineers have gone. With the idea of obtaining a uniform system of reporting these data, and in the hope that the work may be of service to mining engineers in the field, the collecting forms in use are shown in Figs. 1 and 2.

¹ *Bulletin No. 32, August, 1909, pp. 741 to 747.*

² *Bulletin No. 30, June, 1909, pp. 567 to 578.*

³ *Bulletin No. 30, June, 1909, pp. 578 to 579.*

⁴ *Bulletin No. 35, November, 1909, pp. 1027 to 1039.*

⁵ *Bulletin No. 36, December, 1909, pp. 1135 to 1137.*

C. STATION HUMIDITY REPORT (1)

U. S. Geological Survey.

Date.....19..... Hour.....
Mine.....
Station.....
Distance from entrance or shaft.....ft.
Dry bulb.....° Wet bulb.....° Barometer.....in.
Depression (t-t').....° Relative humidity.....
Passage width.....ft. Height.....ft. Area.....sq. ft.
Velocity air per min. reading.....ft. Corrected.....ft.
Volume air per min.....cu. ft.
Intake or return.....
At station, is floor dry or moist?.....
At station, are ribs dry or moist?.....
At station, is roof dry or moist?.....
Method of sampling air.....Sample No.....

FIG. 1.—STATION HUMIDITY REPORT USED BY TECHNOLOGIC BRANCH OF
THE U. S. GEOLOGICAL SURVEY.

D. GENERAL HUMIDITY REPORT (2)

U. S. Geological Survey.

General humidity condition of.....Mine
Is the coal naturally dry or moist?.....
Are the working places dry or moist?.....
Are goaves dry or moist?.....
In entries, is floor clean or dusty?.....
Is dust pure or mixed with rock-dust or clay?.....
In entries, is floor dry or moist?.....
Are ribs and roof coated with dust?.....
Is the above dust dry or moist?.....
Are timbers, if any, coated with dust?.....
Method of humidifying.....
 (a) Sprinkling by cars.....How often?.....
 (b) Sprinkling by hose.....How often?.....
 (c) Are ribs and roof sprinkled?.....
 (d) Water sprays.....Number.....
 How located?.....
 (e) How many hours do sprays run?.....
 (f) Exhaust steam sprays.....
 Where located?.....
 (g) How far does steam fog the air?.....
How much water, by any of above methods, is artificially introduced, in gallons
per minute.....per 24 hours.....
General humidity notes:
.....
.....
.....
.....
.....

FIG. 2.—GENERAL HUMIDITY REPORT USED BY TECHNOLOGIC BRANCH OF
THE U. S. GEOLOGICAL SURVEY.

Coal-dust and its treatment is a large subject, and one upon which hasty conclusions cannot be made. Nevertheless, some preliminary results of tests and observations will soon be published in a bulletin of the U. S. Geological Survey, under the title, Coal-Dust Problem and Proposed Remedies. This paper will include a summary of the experiments abroad and in the United States, and a discussion of the various methods for rendering coal-dust inert, together with the results of the preliminary tests made at the Pittsburg station and of observations made in coal-mines. The experiments have shown that moisture will render coal-dust inert, but the amount of moisture necessary for this effect is considerably in excess of what has hitherto been supposed. Mere dampening does not suffice. Moreover, it was found that the presence of air saturated with moisture is not, *per se*, a preventive of coal-dust explosions, as implied in Mr. Shurick's discussion, but the continued saturation of a ventilating-current does serve to moisten the dust, and if carried to a sufficient degree will render it inert to any ordinary initiating cause.

That explosions of coal-dust occur far more frequently in winter than in summer has been well established. This fact has led to considerable misapprehension that the temperature itself is responsible for explosive conditions, to overcome which it has been suggested that it would be sufficient to warm the intake air in winter. The important facts are that the return-air of a mine of any size is practically uniform in temperature, within a few degrees, winter and summer, and that it is generally in a nearly-saturated state, the relative humidity rarely falling below 90 per cent. Hence, it follows that where no artificial moistening is done, unless the air entering the mine carries the same amount of moisture that goes out of the mine in the return-air, over and above the drainage-losses, moisture is withdrawn to such an extent that the walls of the passageways and the coal-dust are more or less dried; the latter being generally left in an explosive condition during the winter period.

The observations and experiments mentioned indicate that the influence of barometric pressure, the temperature, and the condition of relative humidity at the moment of testing is unimportant; the important feature being that otherwise inflamma-

ble coal-dust in the locality of the initiating cause contains sufficient moisture at the time of exposure to concussion and flame to prevent its being raised and ignited. This percentage varies with the character of the dust, whether pure bituminous coal-dust or mixed with shale or slate, and the size and quantity of the dust particles as well. The experiments show that all dry and pure or moderately pure bituminous and sub-bituminous dusts propagate an explosion under certain conditions.

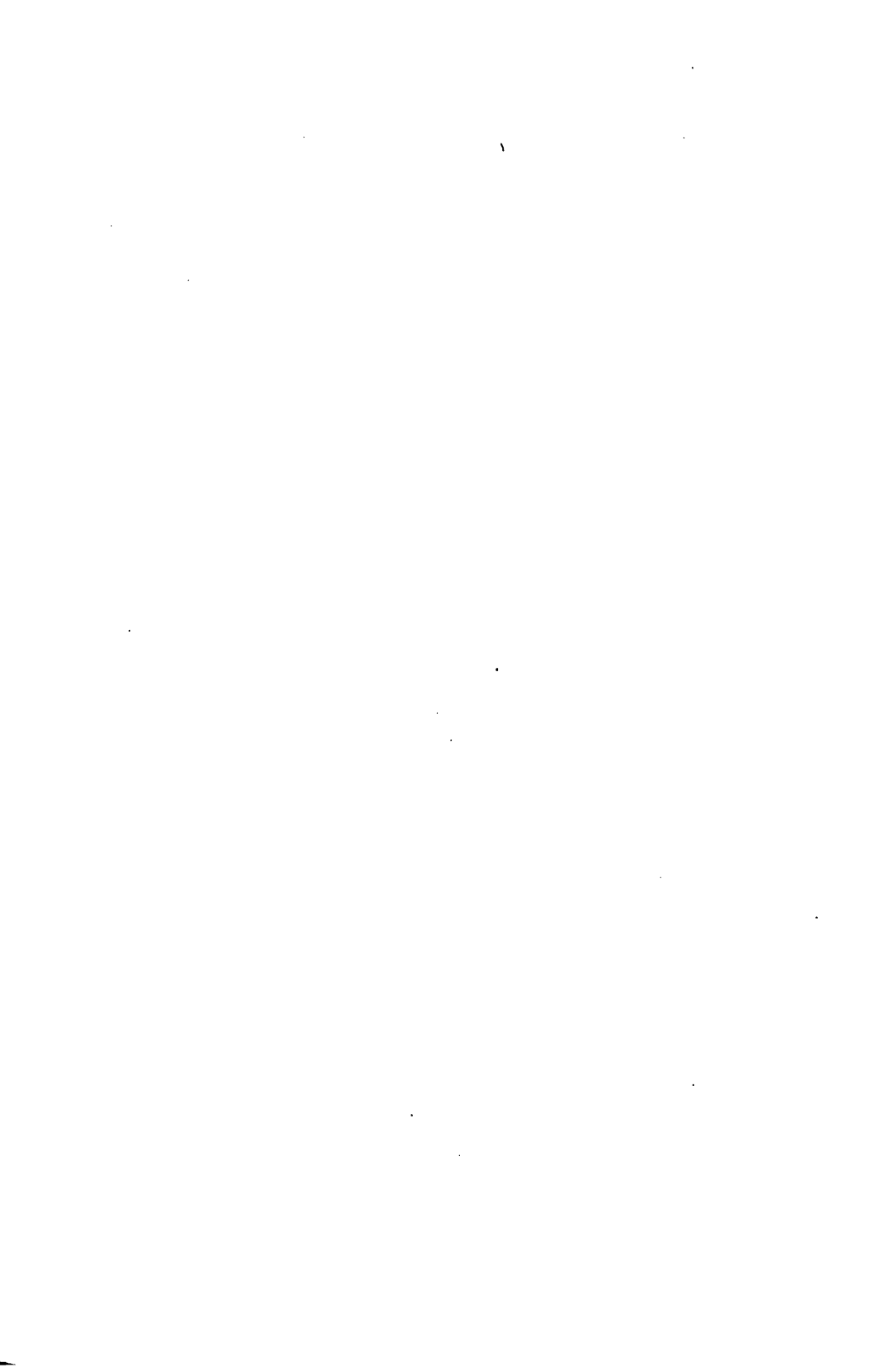
In my opinion, Mr. Mannakee, in his paper on explosions in the Appalachian mines, lays undue stress upon the temperature, barometric condition, and humidity on the day of the explosion. The temperature for a considerable period prior to the explosion is of the utmost importance, but the experiments in the explosion-gallery have indicated that it has no discernible influence as compared with the condition and character of the dust itself. The gallery-tests at Pittsburg show that to render pure, finely-divided bituminous coal-dust inert when exposed to the flame of a blown-out shot, and the flame of the initial combustion, it must be sufficiently wet so that it can be molded in the hand.

While the dangers arising from improper use of explosives in mines have been fully recognized in the several discussions which have appeared in the *Transactions*, and while it is undoubtedly true that if black powder is properly used and the coal sheared and undercut, the greater number of the explosions resulting from this source would be eliminated, it by no means follows that all would be. The use or misuse of explosives is largely in the hands of the operators and miners. States may make laws, but unless the State inspectors are supported by the miners and the operators, the results sought will not be achieved. Not all States require the shearing and undercutting of the coal; and even with this done, black powder, dynamite, or other long-flame explosives in gassy coals may cause fires or explosions. Under the conditions which prevail, and which are too deep seated to be changed by mere advice, the safest proposition is to use the explosives which have been tested by the U. S. Geological Survey in the presence of gas and coal-dust and found not to cause ignition by tests many times repeated, and supplement this selection by efficient humidifying, spraying or wetting throughout the mine.

Observations in the field by the mining engineers of the Sur-

vey have determined that the best and safest arrangement is for all shots to be charged, tamped, and fired, with the use of electric detonators, by picked men, and not merely fired by shot-firers, who do not stop to inspect holes properly and who do not know just how they are charged. A further measure of safety, which would also improve the quality of the coal produced, would be to have the holes drilled by special drill-men. In other words, the use of explosives should not be put in the hands of ignorant, untrained men, or men who take dangerous chances. Speaking as one concerned in operating coal-mines for many years, my observation has been that more overcharged and dangerous shots are made by intelligent English-speaking men who are reckless, and sometimes criminally so, than by the inexperienced foreigners. I call to mind one explosion resulting from three overcharged shots prepared and fired by English-speaking miners, who, knowing these shots to be dangerous, purposely left long fuses, evidently expecting to get out of the mine, which was new and small, before the shots went off. Their plans were miscalculated, however, and the resultant explosion caused not only their own deaths, but the deaths of others as well.

The indirect effect of the misuse of explosives—namely, the weakening of the roof and blowing-out of props—is a most important factor in the large loss of life resulting from roof-falls. In my opinion, close supervision at the face, as pointed out by Mr. Saunders, is most important. The great majority of underground foremen have too much ground to cover, and do not have opportunity to see that the directions about props are observed, nor, in fact, do they get to the face often enough to give such directions. If the Yorkshire system of deputies were adopted in the United States, I believe that there would be a great decrease in the number of accidents at the face. It is urged that the Yorkshire system is more expensive than that followed in the United States, since one deputy has only from 25 to 40 men under him. On the other hand, the decrease in accidents and the increased efficiency of the day or company men, who are under constant supervision, will, in my opinion, more than offset the increased cost; and even if it did not, the additional expense should willingly be paid by the consumer, from a humanitarian stand-point, as part of the cost of coal.



The Behavior of Copper-Slags in the Electric Furnace.

BY LEWIS T. WRIGHT, SAN FRANCISCO, CAL.

(Pittsburg Meeting, March, 1910.)

I HAVE long been aware that ferruginous copper furnace-slag if fused in the electric arc will yield metallic iron containing copper, and in order to confirm this knowledge, and to obtain further information of the behavior of such slags in the high temperature and reducing conditions of the electric furnace, a number of samples of slag were fused in an experimental electric furnace.

The results obtained, given in Table I., show that a very large amount of metallic iron was produced, and that this iron carried with it practically all the copper, gold, and silver, and more than 50 per cent. of the sulphur, of the original slag.

The metallic buttons formed in the electric furnace were clean, hard, but not brittle.

TABLE I.—Results of Fusing Ferruginous Copper-Slags in an Electric Furnace.

Experiment No.	9.	11.	12.	13.	14.	15.	16.
Slag used, grams.	700	700	900	700	700	700	700
Strength of current, amperes.	75	70	70	80	75	75	75
Time of fusion, hours.	1-20'	1-20'	1-15'	1-15'	1	1-30'	1-15'
Weight of button, grams.	186.0	218.78	218.05	216.82	162.82	166.9	152.45
Concentration, per cent.	23.57	30.54	24.32	30.91	23.26	23.84	21.92
<i>Analysis of Slag Used:</i>							
Cu, per cent.	0.55	0.25	0.30	0.28	0.28	0.45	0.38
SiO ₂ , per cent.	36.8	30.1	30.2	30.6	39.6	45.88	38.48
Fe, per cent.	42.3	38.8	38.8	40.1	40.1	40.3	38.3
S, per cent.	.....	.....	.....	.....	.....	1.7	1.47
Ag, ounces per ton.	0.29	0.3	0.27	0.30	0.29	0.33	0.18
Au, dollars per ton.	0.40	0.30	0.30	0.30	0.30	0.30	0.15
<i>Analysis of Iron Button:</i>							
Cu, per cent.	1.62	0.84	1.09	0.82	1.4	1.36	1.62
SiO ₂ , per cent.	0.06	0.46	0.12	0.48	0.6	0.5	0.2
Fe, per cent.	90.91	92.7	94.52	86.0	91.06	91.39	94.26
S, per cent.	4.4	2.25	3.06	1.86	2.9	3.91	3.9
Ag, ounces per ton.	1.4	0.63	0.42	1.11	0.60	0.58	0.48
Au, dollars per ton.	0.80	0.40	0.40	0.50	0.60	1.20	0.80
<i>Analysis of Slag After Fusion:</i>							
Cu, per cent.	0.1	0.05	0.05	0.05	0.05	trace	trace
Fe, per cent.	18.8	6.5	4.9	5.0	6.3	19.31	17.23
S, per cent.	0.4	0.62	0.10	0.22	0.23	0.47	0.55
SiO ₂ , per cent.	51.38	59.0	55.8	63.5	53.8	51.12	51.64
Ag, ounces per ton.	0.025	trace	0.02	0.0075	0.025	trace	trace
Au.	trace	trace	trace	trace	trace	trace	trace

A Commercial Fuel-Briquette Plant.

BY W. H. BLAUVELT, SYRACUSE, N. Y.

(Pittsburg Meeting, March, 1910.)

THE subject of fuel-briquetting has attracted much attention on the part of engineers and investors for the past 15 or 20 years, and especially in recent years, during which a number of plants have been built, with more or less commercial and technical success. Our technical literature contains numerous descriptions of certain processes, and discussions of the industry in general. For a history of the development of the art in the United States, and for descriptions of many of the processes which have been tried, reference may be made to the files of our *Transactions*, and, for more recent information, to a paper by C. T. Malcolmson, read before the First Annual Convention of the International Railway Fuel Association in June, 1909.

The purpose of the present paper is to describe the briquette-plant of the Solvay Process Co. and the Semet-Solvay Co. at Detroit, Mich., which, after a period of long and costly evolution, is now operating satisfactorily on a commercial basis. I believe that it will be of interest to some of our members to have the details of operation, power-consumption, labor, etc., as worked out on a practical and commercial scale in a going operation.

The briquette industry has had a somewhat checkered career in the United States, and much the larger portion of the failures has been due entirely to commercial causes. It seems axiomatic to say that before undertaking the installation of a plant for manufacturing briquettes it is necessary that the local situation should be carefully examined: First, to determine the kind of briquettes, if any, the local market will consume; that is to say, whether the available fuel-supply is such that briquettes would be a welcome addition, and whether the most promising field is the industrial or the domestic market. Second, if there is an available supply of raw material, as coal,

coke, pitch, etc., which can be worked up into briquettes that will meet the market-conditions, and can be obtained at a price that will leave a margin for cost of manufacturing and a suitable profit. If this preliminary investigation does not result satisfactorily, the manufacturer should carry his plans to another place. Although these requirements are axioms of ordinary business prudence, yet neglect to observe them has been the cause of the failure of many undertakings, resulting often in the loss of the entire capital invested.

The next step is the selection of the process of manufacture best adapted to the materials at hand and the quality of briquettes to be produced. A number of different processes and briquetting-presses have been developed, both in Europe and in the United States. In Continental Europe the manufacture of briquettes has reached large proportions, and has become an important industry. The usual shape of the European briquettes is that of a rectangular block with rounded edges, weighing from 10 to 0.5 kg., or less. The larger sizes, which are usually broken up before firing, have the advantage of greater convenience in storing. For household purposes the housewife patiently breaks up the large briquettes with a hammer, but not having been accustomed to prepared sizes of anthracite, the annoyance, dirt, and waste caused thereby are not realized. The smaller briquettes, usually of the eggette form, are largely used, especially in Belgium and parts of France.

There is a sharp line in manufacturing between the eggette and other forms. The eggettes are made on rotary presses, the coal and binder being pressed between the faces of two broad wheels or rolls, having faces which are cupped out to receive and compress the briquettes into form. Generally speaking, it is not practicable on these rotary presses to produce briquettes larger than about 6 oz. in weight. On the other hand, the capacity of the reciprocating presses, which are used in making the larger briquettes, falls off rapidly as the size decreases, and it is usually not commercially economical on these presses to make briquettes which weigh much less than 1 lb. each. Some forms of press have been developed, notably in the United States, which, in a measure, combine the features of the rotary and reciprocating presses, and which would produce briquettes of intermediate size between the European rotary

and the reciprocating press. These machines, however, have not been fully developed to commercial success.

In planning for the Detroit plant the domestic market appeared the most promising, and therefore a rotary type of press was selected which would produce small briquettes, or eggettes, each of about 2 oz. weight. After much experiment, in which it was learned that a good many things must not be done and that a few points were absolutely essential to the success of the operation, the plant was developed as it now stands.

The raw materials used are coke-breeze from an adjacent coke-oven plant, and dry non-caking coal from either the Hocking Valley or the Jackson Hill districts. These materials are used in equal proportions, by weight, mixed with from 8 to 9 per cent. of the binder. Coke-breeze appears to require somewhat more binder than coal; perhaps on account of its porosity, which allows the binder to be absorbed into the cell structure without useful effect. Probably further experience will result in reducing the percentage of binder used. Coal-tar pitch was selected as the binder, since experience has shown that, broadly speaking, it is the only thoroughly successful binder, generally obtainable at a moderate cost, which can produce a water-proof briquette.

Two processes are in general use, one using soft pitch, the other hard pitch. In the former the pitch is melted by steam-heat or in an oven fired with coal or other fuel, and mixed with the solid fuel while liquid, while in the latter process the pitch is made hard enough to permit of its being ground to a fine powder. In practice this latter means that, adopting the usual tar-distiller's test, the pitch should be somewhat harder than can be chewed in the mouth without fracture after the pitch has been permitted to reach the temperature of the mouth. Unfortunately, no more scientific method of testing the hardness of pitch has been agreed upon as yet. The whole subject is in a rather chaotic stage, so the old tar-distiller's chewing-test is still largely employed.

The hard-pitch method was selected for the Detroit plant, partly because the soft-pitch methods are always a source of danger from fire, but mainly because it is believed that the hard-pitch method is the one which should be developed, with a view to obtaining the pitch at the lowest price delivered at the bri-

quette-plant. Hard pitch is more easily transported, either in very cheap packages, or, in cold weather, in bulk, and it can be produced at lower cost, since a larger portion of the more valuable oils contained in the original tar have been removed. Possibly the hard-pitch method requires a slightly larger quantity of binder with some coals, but the lower cost at which it can be manufactured more than offsets this objection, and it also has the advantage of producing less smoke in combustion.

The accompanying diagram, Fig. 1, shows the arrangement of the different parts of the plant.

The process as at present conducted is essentially as follows : The coal is unloaded into a track hopper and elevated to the coal-bin. As slack coal is always used, no preliminary crushing is necessary. The coke-breeze usually contains considerable moisture, so in order to maintain constant conditions the breeze is dried in a rotary drier before being elevated to its storage-bin. The coal and coke are brought together from the bins into a measuring-machine, Fig. 2, which delivers the two materials in any desired proportion to a hammer-mill of the Jeffrey or Williams type, Fig. 3, in which the mixture is finely ground. The pitch which meets the coal and coke in this mill is brought from the pitch-storage shed by a pitch-man, who breaks it into pieces of convenient size for feeding to the pitch-cracker. This cracker consists of a pair of rolls, 16 in. in diameter and 12 in. face, with small V-shaped corrugations, running at a speed of 85 rev. per min. These rolls crush the pitch to about $\frac{3}{8}$ in. in diameter, and give no trouble unless the pitch employed is too soft to retain its brittleness at the temperature of the atmosphere. The crushed pitch falls from the rolls into a small hopper, from which a screw-conveyor, which acts as a measuring-machine, delivers a definite quantity of pitch on to a small belt-conveyor, which in turn discharges the pitch into the mouth of the hammer-mill, as above stated.

By grinding the coal, coke, and pitch all together in the hammer-mill the three materials are thoroughly mixed, and opportunity is given for each particle of the coal and coke to receive a coating of pitch powder, which, of course, is the theoretical condition to be striven for. Practice has shown that in pulverizing coke-breeze the wear on the hammers of the mill is too great, and it is planned to install a small pair of

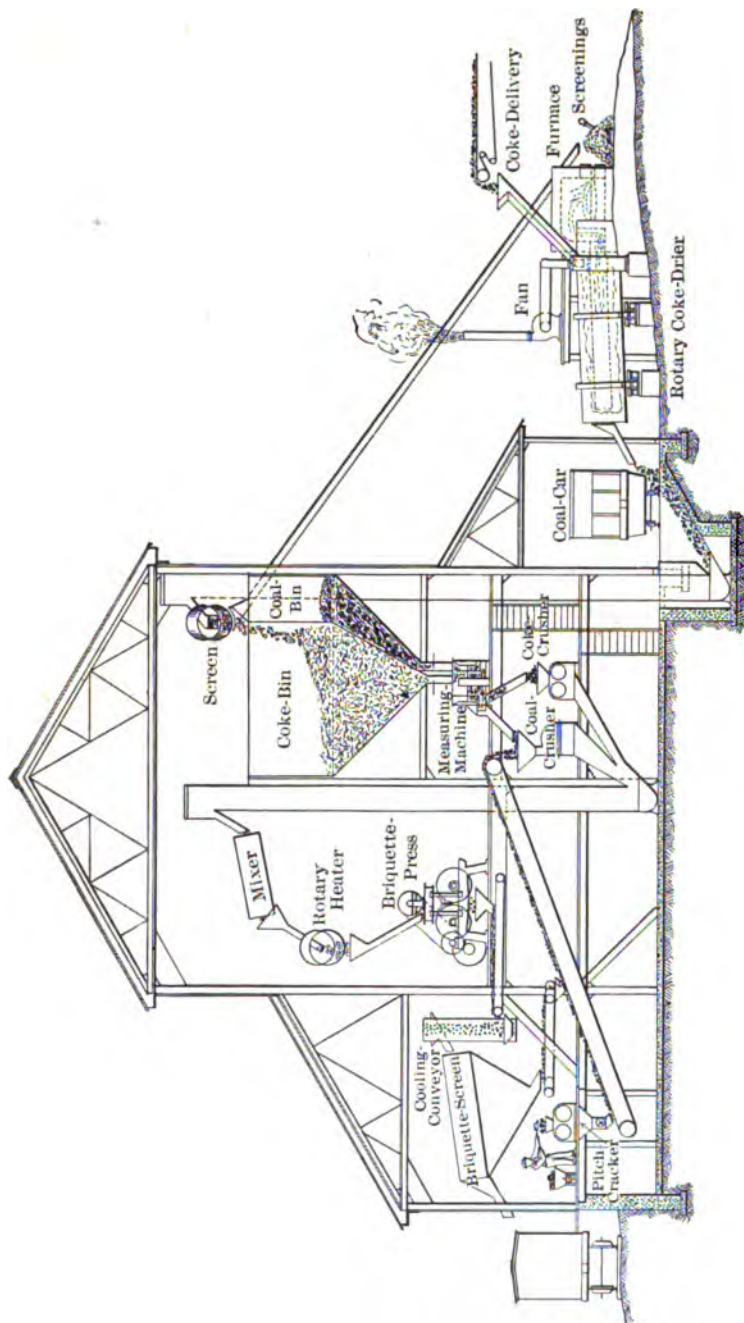


FIG. 1.—DIAGRAM SHOWING THE ARRANGEMENT OF THE FUEL-BRIQUETTE PLANT OF THE SOLVAY PROCESS CO. AND THE SEMET-SOLVAY CO., DETROIT, MICH.

chilled-iron rolls for pulverizing the coke, leaving the hammer-mill for the coal and pitch. The pulverized coke, coal, and pitch will be delivered direct to an elevator-boot, which raises the mixture to the top of the building. From this elevator the mixture is conveyed in a rotary conveyor, in which the different ingredients are thoroughly mixed, to the rotary heater, Fig. 4, consisting of a cylinder, 40 in. in diameter and 21 ft. long, set at a slight inclination. By the revolution of this cylinder the mixture passes from the upper to the lower end and is thoroughly mixed thereby. The cylinder is also heated to a temperature of about 80° C. by superheated steam introduced through a perforated pipe extending the length of the cylinder. This steam is superheated by the waste heat from the coke-breeze drier. In this manner the several components have been accurately and uniformly proportioned, pulverized, mixed, and heated to a controlled temperature; also, a small quantity of water has been introduced, which is desirable to insure a pliant and readily moldable material for the press. In some processes a vertical cylinder with stirrers is employed instead of a horizontal rotating cylinder, the mix being heated with superheated steam in a similar way.

From the mixing-cylinder the material is delivered by a short chute to the feed-box over the rotary press. The press used at this plant, Fig. 5, is of French manufacture and of the standard Belgian type. It consists of a heavy frame supporting two rolls, each of which carries in the middle a gear having 7-in. face and 2.5-in. pitch, and on each side of the gear a steel tire, 5.25 in. wide on the face by 2.5 in. thick. These gears and tires are accurately fitted on to the drum or roll, and keyed and bolted to place. The faces of the tires are hollowed out or cupped into recesses about 2.25 in. long and $1\frac{1}{2}$ in. wide. There are three rows of these cups, arranged as closely as possible, so that each tire contains 207 cups. The rolls are accurately registered, so that the cuppings in the adjacent tires shall produce the egg-shaped briquette, the shape and dimensions of the cuppings determining the form and weight of the briquettes. Provision is made for turning up the faces of these steel tires as they wear and for cutting out the cups, so that the life of the tires may be thereby prolonged. It is found that the wear is much greater with coke-breeze than with coal



FIG. 2.—STORAGE-BINS AND MACHINE FOR DELIVERING MEASURED PROPORTIONS OF COAL AND COKE.



FIG. 3.—HAMMER-MILL FOR PULVERIZING THE COAL AND COKE.



FIG. 4.—ROTARY HEATER AND MIXER. THE SUPERHEATED STEAM ENTERS AT THE LEFT-HAND END.



FIG. 5.—BRIQUETTE-PRESS. THE FEED-CONTROL LEVERS TO ONE PAIR OF ROLLS ARE SHOWN DIRECTLY UNDER THE FEED-BOX.

alone, and it is proposed to substitute rolls with a chilled-iron face in place of the steel. It has been found in our experiments that even the alloy-steels, especially designed to resist wear, are not as satisfactory as chilled cast-iron. The cutting-action of the sharp particles of coke wears the best manganese-steel, for example, perhaps even more rapidly than ordinary tool-steel.

Adjustments are provided on the frame of the press which allow the rolls to be brought together as the tires wear or are dressed down. The rolls are driven by means of a pinion engaging one of the pair of gears. The pinion-shaft in turn is driven through gearing by a belted motor. The belt affords a convenient safeguard in case of foreign material getting between the rolls and blocking them. If a direct drive is used, carefully-designed breaking-pins are essential.

The mix which has been delivered into the feed-box is constantly stirred therein by rotating paddles, and fed down to the rolls through two chutes, specially arranged with sides which may be moved in parallel, thereby controlling the feed of the mix to the rolls. It is essential to the production of uniform briquettes that, in addition to the mix being uniform in composition and temperature, the quantity delivered between the rolls must be accurately controlled, since it is the resistance of the material itself which determines the amount of pressure under which the briquette is produced.

From the press the briquettes fall on a conveyor-belt and are delivered to a cooling-conveyor outside of the building. This cooling-conveyor is a slow-moving rubber belt of sufficient length to permit the briquettes to cool sufficiently so that the pitch will harden and give strength to the briquette to resist breakage as it passes through the screen and falls into the railroad-car. At some plants the cooling-conveyor is constructed of a woven-wire belt, which would seem to be advantageous in that it gives greater access of air to all sides of the briquettes. When the briquettes have been sufficiently cooled to have acquired the necessary toughness, they are delivered from the cooling-conveyor to a rotary screen, which separates out any fine material and knocks off any fins which may adhere to the briquette on account of wear of the rolls. From the rotary screen the briquettes fall into railroad-cars for shipment, or

into storage-piles. A small conveyor returns the fine unbriquetted material and the fins to the plant and delivers it back to the hammer-mill, so that it is pulverized and thoroughly mixed with the new material.

The capacity of this plant has not yet been fully developed. It has been brought up to 9 tons per hour, and it may reach 10 tons. The main features of the plant are, however, arranged to have a capacity equal to the output of two presses, and it is the purpose, as the market develops, to add the second press. This addition would result in a very material reduction in the cost of operation, since the labor required will be but little more than at present, about two more men. The power required for operating the elevators, conveyors, etc., and the repairs on these parts of the plant will be but little more than at present when the tonnage has been doubled. Probably the power required and the wear on the pulverizing-mills, presses, and some other parts will be more nearly in proportion to the tonnage. An examination of the costs given below, based on the output of one press and two presses, shows very clearly the effect of output on the cost of briquette manufacture.

Repeated readings have been made of the power consumed in the different parts of the plant, with the following average result:

Motor Driving.		B.h.p.
Breeze-conveyor to drier,		1.50
Breeze-drier and ventilating-fan,		2.85
Pulverizing-mill,		22.00
Elevator-shafting and rotary mixer,		10.00
Briquetting-press,		25.00
Total,		61.35

The press-motor also drives the cooling-conveyor, rotary screen, pitch-cracker, and conveyor.

The consumption of steam in the rotary heater and mixer depends partly upon the temperature of the atmosphere and partly upon the quantity of binder and its melting-point. Tests at the Detroit plant, extending over a number of days, show a consumption of 206 lb. of steam per ton of briquettes produced. This result was during a period of somewhat slow operation. No tests have been made during a period of steady running at full speed, but the above steam-consumption per ton of product

would undoubtedly be decreased by a larger output. The superheating of the steam is desirable in order to maintain it in a dry state, and prevent the addition of too much water to the mix. The experiment was tried of heating the outside of the rotary mixer and heater with a gas-flame, but the use of superheated steam seems to be more satisfactory.

The labor on a plant similar to the one described is approximately:

	Cost Per Hour.
1 foreman,	\$0.50
1 press-man,	0.26
1 oiler, breeze-drier- and conveyor-man,	0.18
1 pitch-man,	0.18
1 briquette-loader,	0.19
2 laborers, at 17 cents,	0.34
Total,	<u>\$1.65</u>

When producing 9 tons of briquettes per hour, the labor-cost becomes 18.3 cents. Two presses would double the output, but would only require two more men at 18 cents, and a second press-man at 26 cents per hour, which would bring the labor-cost to 12.6 cents per ton.

The use of coke-breeze increases the wear on all apparatus with which it comes in contact, but most especially on the briquetting-rolls. The question to be determined in each case is whether the breeze can be obtained at a cost sufficiently low in comparison with coal to offset the increased repairs due to its use. In addition, coke-breeze has the advantage of being smokeless, so that its use reduces the smokiness of soft-coal briquettes. The difference in cost of maintaining the briquetting-rolls with and without coke-breeze is so great that two cost-sheets are given below, which will illustrate the approximate cost of manufacturing briquettes under these two circumstances in a plant similar to that here described, producing 9 tons of briquettes per hour. If the plant were operated on the basis of the larger production obtained from two presses, it would be safe to estimate a reduction in these two costs of, say, 10 cents per ton.

	Cost Per Ton of Product.	
	Using 50 Per Cent. of Breeze.	Using 100 Per Cent. of Coal.
Labor,	\$0.183	\$0.183
Power, at 1.25 cents per kw-hr.,	0.072	0.072
Steam, 206 lb., at 0.5 cent per h.p-hr.,	0.034	0.034
Breeze-drier and superheater fuel,	0.03	0.011
Miscellaneous supplies, oil, waste, lights, and water,	0.03	0.03
Repairs on rolls,	0.191	0.035
Other repairs,	0.05	0.035
Total,	\$0.60	\$0.40

To obtain the total operating-cost of a plant such as has been described, and operating under similar conditions, the cost of the pitch for binder and of the coal, coke-breeze, or other fuel used, must be added to these figures.

In order to have an illustration of such costs, let us assume that suitable slack coal can be obtained at \$2, coke-breeze at \$1, and pitch at \$8 per ton, delivered at the plant. Since, as above pointed out, the use of breeze requires somewhat more binder, we will assume the use of 7.5 per cent. of binder with the coal and 9 per cent. with the mixture of coal and breeze.

	Cost of One Ton of Briquettes.	
	All Coal.	Equal Parts of Coal and Breeze.
0.455 ton coal, at \$2, . . . . .	.....	\$0.91
0.925 ton coal, at \$2,	\$1.85	
0.455 ton breeze, at \$1, . . . . .	.....	0.455
9 per cent. of pitch, at \$8, . . . . .	.....	0.72
7.5 per cent. of pitch, at \$8,	0.60	
Cost of briquetting, as above,	0.40	0.60
Total,	\$2.85	\$2.685

Many coals can be briquetted with less than the above quantities of pitch, and, of course, the costs of coal and coke-breeze vary at every plant, but the substitution of local prices in the above tables will give approximately the cost of briquettes in a plant having about the capacity of the one described. In larger plants the cost of operation is less, and with briquettes of large size for industrial purposes the cost would be materially reduced.

In contemplating the erection of a plant, not only must a press be selected suited to the material to be treated and also to the kind of briquette demanded by the available market, but it must be remembered that a briquette-plant includes much

more than the mere press. To insure economical operation, the preparation and handling of the material must be carefully studied and planned for, and the whole combination of driers, bins, elevators, measuring-machines, crushers, mixers, heaters, conveyors, etc., must all be combined with the press into a single effective and economical unit, which will insure a uniform proportioning of the materials, their thorough and intimate mixture, their heating to a sufficient and uniform temperature, and their delivery to and removal from the press at a constant and reliable rate. If the various units entering into a briquette-plant are thus successfully combined with careful economy of power and convenient arrangement, so that the labor is maintained at a minimum, a briquette-plant should be a reliable and assured source of profit in locations where a satisfactory raw material and market for the product obtain. While the processes are simple and easily understood, it is essential that the different conditions be rigidly maintained, and usually it is only after the press-man and other more important operatives have attained certain instinctive recognition of the conditions that the plant becomes thoroughly successful.

The Combustion-Temperature of Carbon and Its Relation to Blast-Furnace Operation.

BY CLARENCE P. LINVILLE,* STATE COLLEGE, PA.

(Pittsburg Meeting, March, 1910.)

It is recognized that, in all metallurgical operations, the greatest possible uniformity in all conditions is essential to the best results. It is the constant aim of metallurgists to secure this uniformity, and their success in this respect has been in many cases the cause of great advances in the metallurgical processes themselves.

Of all such processes, the production of pig-iron in the modern blast-furnace is perhaps the most complex and the most difficult of control. Notwithstanding the great progress of recent years, there is still great difficulty in obtaining anything like uniform conditions and results in the manufacture of pig-iron. The reason is not far to seek. The ores vary in composition and physical properties, often carrying a varying amount of gangue material, unevenly distributed. The coke may vary in composition, cell-structure, moisture, hardness, and other properties. The blast, the weight of which far exceeds that of any other constituent, varies in its moisture-content and consequently in its chemical composition; and its temperature, by reason of the method of heating, is not uniform, but, besides varying from time to time with atmospheric and other outside conditions, has a maximum and minimum for every changing of stoves.

Now, with regard to these variations, the modern demand for uniformity has been greatly aided. Chemical analysis has made it possible to select ores so that the composition of the charge can be kept fairly constant; coal may be obtained from a given field, and coked in the same kind of ovens under conditions which make the fuel practically uniform; the Gayley

* Associate Professor of Metallurgy, School of Mines and Metallurgy, the Pennsylvania State College.

dry-blast process has rendered the composition of the air almost constant, by reducing the amount of moisture to a constant quantity; and the temperature of the blast is often maintained almost constant, either by the use of "equalizers," or by the admixture of cold air with the hot blast.

An important point, however, which indeed has not been entirely overlooked, but which has not received the consideration it deserves, is the hearth-temperature. It would seem to be a matter of the greatest importance to maintain the temperature of the blast-furnace hearth at a uniform point, if possible. Many furnace-troubles may be traced to a changing hearth-temperature, and if it were possible to maintain this constant, it is probable that these troubles would be greatly diminished.

The temperature of the hearth is determined by several factors, notably: the temperature of the burning coke; the amount of material to be fused; the melting-points of the materials fused; the reactions other than carbon-combustion; and irregularities, such as slips, which cool the hearth by precipitating cold material into it. Of these, the variables are the combustion-temperatures and the irregularities due to slips. It is probable that if the variations of the first of these could be overcome, the effect of the latter would be greatly diminished. Combustion-temperature, then, is the important consideration. The higher the combustion-temperature, other things being equal, the higher will be the temperature of the hearth, and the more rapid will be the rate of fusion of iron and slag.

The lower portion of our iron blast-furnace may well be considered as having several zones. In the lower part of the hearth is found the melted pig-iron, covered with a thick layer of melted slag. Once the pig-iron has reached the hearth, there is little chance for any further change in it. Its temperature may be increased through contact with the slightly hotter cinder, but this is partly counteracted by conduction to the ground and the walls of the hearth. The slag, being in direct contact with the combustion-zone, has a much greater opportunity to become superheated, and is only deterred from reaching a temperature approximating the combustion-temperature by the fresh material constantly melting and falling into it. The hottest part of the furnace is undoubtedly just in front of and above the tuyeres, where the coke is burned. The hot

gases, as they rise, give up their heat rapidly to the descending materials.

At a greater or less distance above this place will be found the fusion-zones, first for slag, and higher for pig-iron. This distance will depend in each case upon the temperature of the combustion-zone, the melting-points of the materials, and the rapidity with which they pass downward through the furnace.

It can be readily seen that, given the proper temperature, and the amount of slag and iron to be melted, an increase in the amount of coke can only result in delaying the operation of the furnace, since this coke has to be burned out before the material to be fused can descend.

Any change in the temperature of the combustion-zone will change the position of the fusion-zones, an increase in temperature causing them to move upward, and a decrease causing them to move downward. Increasing the burden would also somewhat lower the fusion-zone.

It is probable that much of the trouble from hangs, slips, and scaffolds can be traced to these shiftings of the fusion-zones. It would seem to be of the greatest advantage to be able to maintain the fusion-zones as nearly stationary as possible, and in order to bring this about, with a given burden, it is necessary to maintain a uniform temperature of combustion.

Much has been said about the utilization of the heat-units delivered to the furnace. But much more important is the consideration of the temperatures produced by these heat-units. Keep the temperatures right, and the heat-units have a tendency to take care of themselves. It would matter little how much fuel were burned, or how many heat-units furnished to the blast-furnace, if the hearth-temperature was not maintained at a point above the melting-point of the slag produced. Keep the temperature above this point and the furnace will run. The higher the temperature the more rapidly it will run, provided there is not so much fuel present as to hinder the descent of fresh material.

Combustion-temperature is, then, the important point, the amount of slag and iron melted in a given time depending almost wholly upon the surface exposed and the temperature of the gases passing around the melting particles.

The factors to be considered in determining combustion-tem-

peratures are the reactions of combustion and the temperature of the reacting substances. When these are uniform the temperature of combustion will be uniform; but if, for any cause, there are variations in any factor the temperature will be immediately affected.

If we assume that in the blast-furnace the conditions are maintained as nearly constant as possible, that the burden remains the same, the amounts of slag and pig-iron are the same, and the reactions involved in their formation and fusion are consequently the same, then it will be the reactions of combustion of the solid carbon which affect the hearth-temperature; and it may be expected that the temperature of the hearth will vary directly as the temperature of combustion of the solid carbon, being, of course, somewhat lower, but by an amount which is bound to be almost constant for a given set of conditions.

The factors which control the combustion-temperature of solid carbon in the blast-furnace are the composition of the air used and the temperature to which it has been preheated. The temperature obtained will be the result of the heating of the gaseous products of the combustion by the heat which is available, from the combustion of the carbon, from the sensible heat in the air, and from the sensible heat in the solid carbon at the moment of combustion. (Since the air contains more or less water-vapor, this must be taken into consideration.) It may be assumed that the carbon particles have become heated to the temperature of combustion at the moment of the combustion itself.

In order to investigate the relations between temperature of combustion, blast-temperature, and moisture-content of the air used, I have calculated the combustion-temperatures of solid carbon for the following four conditions: ¹

¹ I do not claim special originality for these calculations. They were based on the work of Prof. Joseph W. Richards, as given in his articles on Metallurgical Calculations, and afterwards in his book on that subject. I have used also the graphic method described by Damour and Queneau, in their book on "Industrial Furnaces." To Mallard and Le Chatelier I am likewise indebted. Specific heats and heats of reaction were taken from Professor Richards's articles in Vol. I. of his book. Since I employed his constants, it is not surprising that my results should closely coincide with his. But I was not aware that he had made calculations of the combustion-temperature of carbon under various conditions until I saw them in his second volume after my own were finished.

a, blast-temperature, 0°C ., dry blast; *b*, blast-temperature, $1,000^{\circ}\text{C}$., dry blast; *c*, blast-temperature, 0°C ., 20 grains moisture per cubic foot; *d*, blast-temperature, $1,000^{\circ}\text{C}$., 20 grains moisture per cubic foot. These values are found to be: *a*, $1,675^{\circ}\text{C}$.; *b*, $2,510^{\circ}\text{C}$.; *c*, $1,360^{\circ}\text{C}$.; *d*, $2,260^{\circ}\text{C}$. Since most American furnace-men prefer to deal with the Fahrenheit scale, I have also calculated the following values:

<i>a</i> . Blast-temperature, 0°F ., no moisture,	3,018° F.
<i>b</i> . Blast-temperature, $1,600^{\circ}\text{F}$., no moisture,	4,853° F.
<i>c</i> . Blast-temperature, 0°F ., 20 grains moisture,	2,453° F.
<i>d</i> . Blast-temperature, $1,600^{\circ}\text{F}$., 20 grains moisture,	3,885° F.

Using the values given in Fahrenheit degrees, I constructed a chart (Fig. 1) showing the relations for all moisture-contents up to 20 grains per cubic foot, and for all temperatures up to $1,600^{\circ}\text{F}$.

This chart is not strictly correct, since it assumes that all temperatures of combustion will be proportional to the differences from the figures given. As a matter of fact, there is a slight variation, but not enough to make any essential difference in the results. The combustion-temperature lines should show a slight upward curve.

This chart shows that changes in combustion-temperature may be due to either or both of two things. If the blast-temperature be maintained constant, the combustion-temperature will vary with the amount of moisture. Roughly speaking, it may be said that each grain of moisture per cubic foot of air will lower the combustion-temperature about 25°F . If the amount of moisture remains constant, increase of the blast-temperature will raise the combustion-temperature, the amount being, roughly, 85°F . or every 100°F . increase in the blast-temperature. It may also be seen that the decrease in combustion-temperature due to 1 grain of moisture may be compensated by carrying a blast-temperature about 30° higher.

Most furnace-managers make some attempt to regulate the hearth-temperature by controlling the blast-temperature, but

That part of this paper for which I may claim originality is the diagram showing the relations between the moisture-content of the air, the blast-temperature, and the resulting theoretical temperature of combustion; and the application of this diagram to the problem of the control of combustion-temperatures, and thus, incidentally, to the attainment of uniformity in blast-furnace operations.

they do this only by observing the operation of the furnace, and making the correction by raising the blast-temperature after it has become evident that the hearth is cooling. If the blast-temperature could be so maintained that the cooling did not take place at all, the practice would be much better.

The problem is solved in the Gayley dry-blast plants by maintaining a uniform moisture-content, thus making it a simple matter to maintain, by means of a very nearly uniform

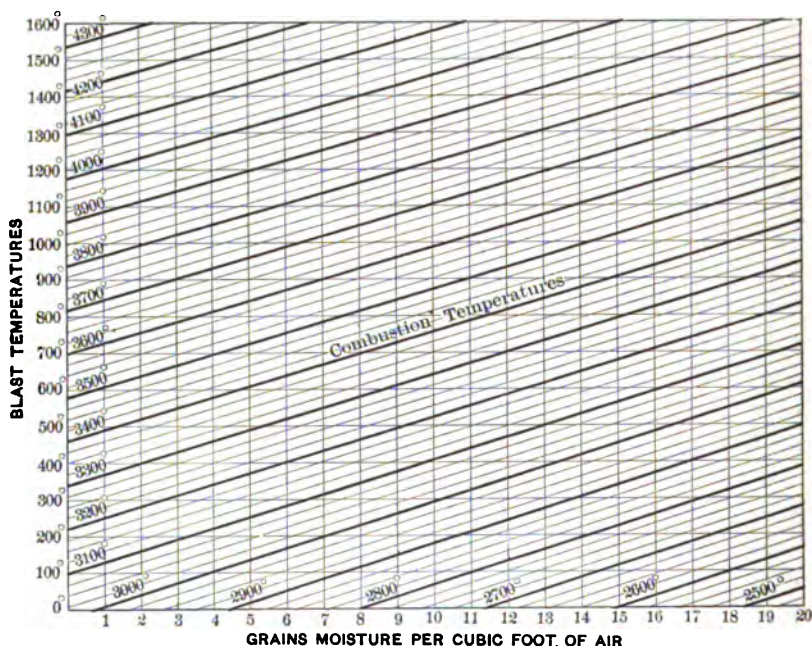


FIG. 1.—CHART SHOWING RELATIONS OF BLAST-TEMPERATURE, MOISTURE-CONTENT, AND COMBUSTION-TEMPERATURE.

blast-temperature, a nearly uniform combustion-temperature, thus securing a practically uniform operation of the furnace.

For the plants that have not as yet installed desiccating-plants for the air, it is probable that much benefit would follow a more careful attempt to control the temperature of the hearth through hot-blast manipulation. This has been suggested before, but has generally been put aside as not valuable enough to compensate for the trouble involved. Yet it would seem to be a simple and not very difficult matter if undertaken by careful men and in the proper spirit.

An experiment in such temperature-control would surely be well worth the time and trouble involved; and for such an experiment the following plan is suggested :

Let a blast-furnace be selected where the burden can be maintained fairly uniform and the fuel-supply fairly regular. Ample stove-capacity should be available, so that there shall be no difficulty in increasing the blast-temperature when needed. Arrangements for the admixture of cold blast should be provided, and the aim should be to maintain the blast at a constant temperature through cold-blast admixture rather than to suffer the variations due to the cooling of the stoves, and the changing from a cold stove to a hot one.

Moisture-determinations should be taken every hour with a sling-psychrometer in the current of air drawn into the blowing-tubs. If more than one engine is running on a furnace, the average of determinations taken at the different engines should be taken; and a certain combustion-temperature should be agreed upon as the proper one to be maintained during the test.

From the moisture-determinations, it will be a simple matter to determine the proper blast-temperature which should be maintained. This can be done by reference to such a chart as is shown in Fig. 1. The stove-tender should then be instructed to maintain this temperature until the next reading is taken.

Such an experiment is surely well worth the trial, and might help to solve the problems due to irregularity of air-composition and combustion-temperatures. If uniformity is the principal reason for the success of the Gayley process, similar advantages should be obtained from the uniformity secured by the control suggested above. The effects, however, of the entire absence of moisture in the blast, and the absence of hydrogen in the combustion-gases, cannot be thus controlled.

In order to illustrate the close relations between combustion-temperature and furnace-operation, the following results, obtained from a recent blast-furnace test, are given :

The test was made in February, 1909, on a 300-ton furnace, covering the operation of the furnace for 72 hours; and was primarily designed to determine the heat-distribution.

The necessary data were obtained by hourly determinations

of the moisture of the blast; hourly analyses of downcomergases; continuous record of blast-temperature taken by a re-

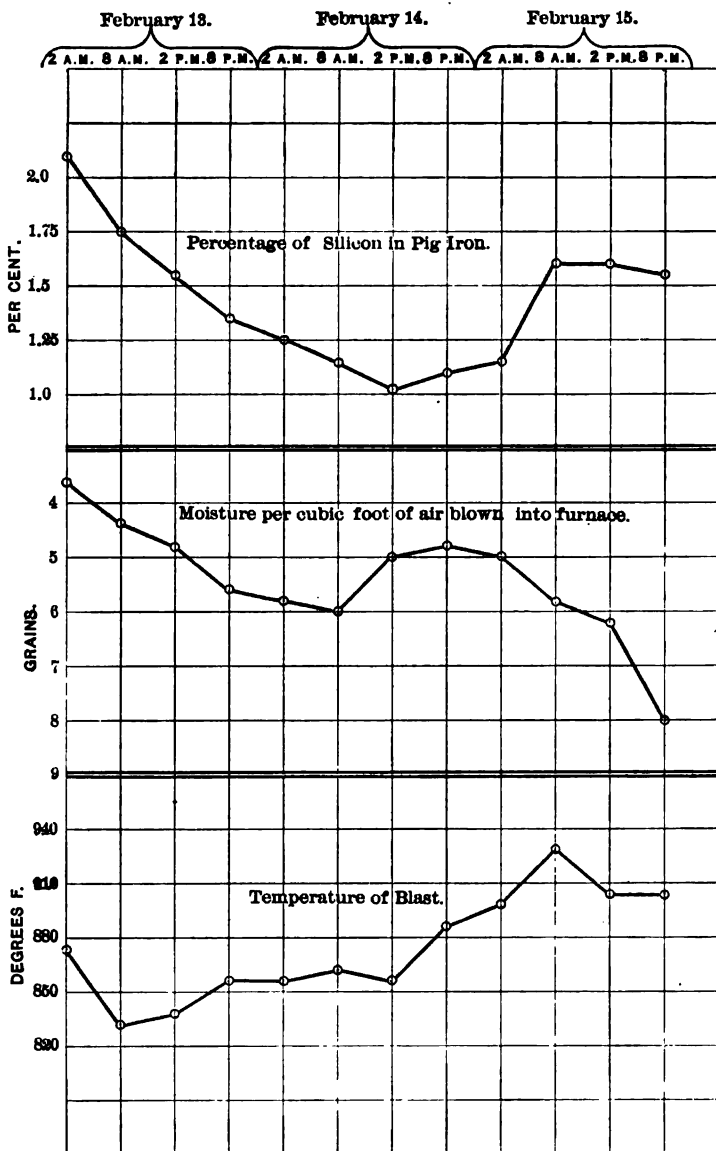


FIG. 2.—CHART OF AVERAGE RESULTS OF BLAST-FURNACE OPERATIONS.

cording-pyrometer; record of weight and analyses of samples of each cast of pig-iron; samples and analyses of each flush of

cinder, accompanied with determination of the temperature by the Fery radiation-pyrometer.

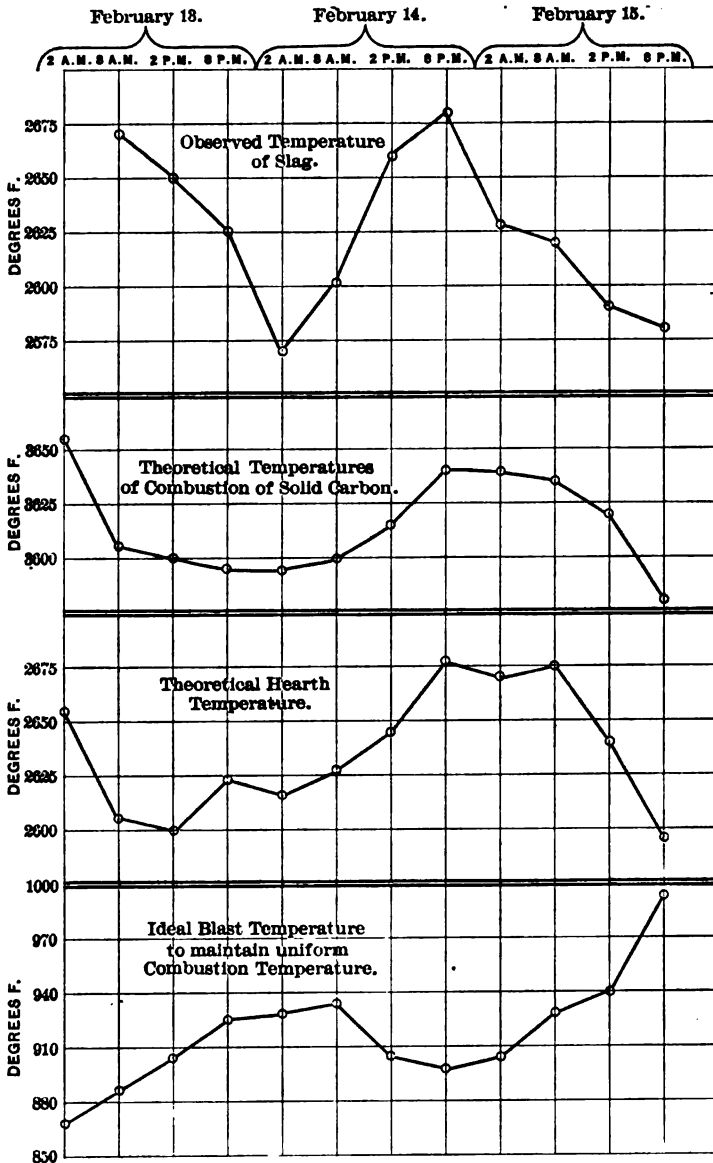


FIG. 3.—CHART OF AVERAGE RESULTS OF BLAST-FURNACE OPERATIONS.

In order to investigate the effects of combustion-temperatures on the working of the furnace, calculations have been made

of the theoretical combustion-temperatures during the test, and the results obtained have been compared with those of the furnace-operation.

Hearth-temperature cannot as yet be judged by any direct means, so we have to rely upon certain indirect methods for determining relative hearth-temperatures.

With a uniform burden and slag-composition, the percentage of silicon in the pig-iron may be taken as a fair indication of the temperature. The higher the silicon the higher the hearth-temperature; hence the percentage of silicon in the iron from cast to cast should follow somewhat closely the theoretical combustion-temperature.

The temperature of the slag flowing from the furnace should also depend upon the combustion-temperature, and should vary, other things being uniform, with it. It will be interesting then to compare the results found with these assumptions.

The readings and calculations have been averaged for the periods between the casts, and the results have been plotted as shown in Figs. 2 and 3.

In these diagrams the curves show: The percentage of silicon in each cast; the moisture in the blast, in grains per cubic foot; the temperature of the blast; the observed temperature of the slag; the theoretical combustion-temperature; the theoretical hearth-temperature, corrected for the basicity of the slag; and the ideal blast-temperature for maintaining a uniform temperature of combustion of $3,650^{\circ}$ F.

In reference to these curves, it may be explained that an attempt has been made to plot them on a uniform scale, so that the results will be easily comparable.

A slight change in burden was made at the end of the first 24 hr., lowering the amount of iron but increasing the amount of slag.

The slag-temperatures were taken as carefully as possible; but in some cases it was difficult to secure accurate readings, fumes arising in clouds from the surface of the slag so as to obstruct some of the heat-rays. It is thought, however, that the averages shown are very close to the proper values.

The line representing theoretical hearth-temperatures is drawn empirically on y. It assumes that the hearth-tempera-

ture is about that of the slag, or about $1,000^{\circ}$ lower than the combustion-temperature of the solid carbon.

Allowance was also made for the differences in fusion-temperatures of the slags, it being found that a difference of about 70° F. existed between the more basic and the less basic. The mean of these was taken as a base-line for corrections, and the degrees of the fusing-temperature above or below this mean were added to or subtracted from the combustion-temperature after subtracting $1,000^{\circ}$.

It will be noted that at the beginning of the test the percentage of silicon in the pig is fairly high; that it rapidly decreases for about a day and a half, when it rises to a maximum at the end of two days and a half, then falling somewhat at the end of the test.

A remarkable similarity will be observed among all of the curves in that their general shape is the same, and their maxima and minima correspond very well with each other and with the silicon-curve.

The curve for observed slag-temperature follows almost exactly the corrected hearth-temperature curve, as indeed it should do.

The effect of moisture on the slag-temperature is well illustrated; its effect on hearth-temperature evidently being somewhat greater than the calculations show. The amount of moisture varied greatly during the test, running from 3.7 grains per cubic foot at the beginning to a little more than 8 grains at the end. The bad effects of this excessive moisture were, however, largely counteracted by the gradually increasing blast-temperature.

The conclusions to be drawn from the test, so far as hearth-temperatures are concerned, seem to be about as follows:

The effects of lowering the theoretical temperature of combustion are to give a cooler slag and an iron lower in silicon.

The lowering of the silicon follows very closely the fall of the theoretical temperature of combustion, but the raising seems to lag somewhat behind the increase of the combustion-temperature.

The effects of moisture in the blast may be compensated by increasing the blast-temperature, so far as it concerns hearth-

temperature, the temperature of the slag, and the composition of the pig-iron.

The temperature of the slag follows very closely the calculated combustion-temperature, being, of course, much lower.

In connection with the regulation of the hearth-temperature, the last curve is given as an illustration of what the blast-temperature should have been, so as to give a uniform combustion-temperature of $3,650^{\circ}$ F., this being about the temperature at the beginning of the test. The temperatures used for this curve are as follows:

	Moisture. Grains.	Blast- Temperature. Degrees F.		Moisture. Grains.	Blast- Temperature. Degrees F.
1, . . .	3.7	868	7, . . .	5.0	908
2, . . .	4.4	886	8, . . .	4.8	900
3, . . .	4.9	904	9, . . .	5.0	908
4, . . .	5.7	925	10, . . .	5.8	928
5, . . .	5.8	928	11, . . .	6.2	940
6, . . .	6.0	935	12, . . .	8.0	992

If we should assume that the amount of moisture had been held uniform at 2 grains per cubic foot, the same result could have been obtained by maintaining a blast-temperature of 820° F.

Pan-Amalgamation: An Instructive Laboratory-Experiment.

Discussion of the paper of H. O. Hofman and C. R. Hayward, presented at the New Haven Meeting, February, 1909, and printed in *Bulletin No. 30*, June, 1909, pp. 513 to 529.

GEORGE W. RITER, Salt Lake City, Utah (communication to the Secretary*).—In their paper, Messrs. Hofman and Hayward deal with a branch of silver metallurgy that is on very uncertain ground, both as a commercial process and as a metallurgical science; moreover, its field is limited to few localities and to peculiar conditions. The literature on the subject is incomplete and full of conflicts. The paper under discussion clears up no disputed points; on the contrary, because of hasty generalization, its tendency is towards further confusion.

In Table I., the authors assume that each test-lot of 1,800 g. of ore contained exactly 5.499 g. of silver, that any variation in the quantity of silver recovered, however slight, should be ascribed to variation in the time of grinding. It is barely possible that the ore was mixed so uniformly as to justify this assumption; but those of us who know how difficult it is to get uniform samples of any ore in which silver mineral is present in rich particles will have a doubt on this point.

The unlikelihood of getting absolutely uniform test-lots of ore also reflects on the data in Table II., on the effect of varying the amount of salt in a pan-charge. The authors say: "The salt series was the last one that was investigated." This again raises a question as to whether the ore was split into test-lots at the time of sampling, or whether it was kept in bulk in such a way as to permit mechanical concentration of values before the end of the experiments.

The conclusion following Table II.: "There is no reason, therefore, for going beyond six per cent. of salt," is hardly to the point. If we assume that salt is of benefit *only* when in solution, it follows that the relation between the quantity of salt

* Received Feb. 3, 1910.

and the quantity of water is of more consequence than the relation between the quantity of salt and the quantity of ore. Water will hold 26 per cent. of salt at the point of saturation; then why add 180 g. of salt to only 500 cc. of water, as was done in the experiments detailed by the authors?

In discussing the results from the use of blue vitriol, the authors overlook, as so many writers have done, the chemical effect of metallic iron, an excess of which is always presented by the pan parts and liners. It can be demonstrated that the blue vitriol ceases to remain in solution after coming in contact with the pan iron, the copper being completely precipitated in metallic form, and being afterwards taken up by the mercury.

In every pan-charge to which salt and blue vitriol have been added, soluble chlorides and sulphates of iron and of sodium will be found. These secondary compounds do act in some beneficial way in the treatment of sulphides of silver, and a quantitative study of their effects might open up a fruitful field. The statement: "The addition of blue vitriol to the pan, as shown in Table V. and Fig. 9, has no beneficial effect whatever; on the contrary, the extraction decreases," is apt to be misleading to the casual reader who fails to note that in the ores used for experiment practically all of the silver was in free state.

Several years ago, while in charge of a large pan-mill, I made a long series of test-runs in a 30-in. experimental pan as well as in the regular 5-ft. mill pans, sometimes substituting cement and wood for the iron pan-parts, and using nearly every common mixture of ores and reagents. Careful sampling of each test-lot of ore, both before and after treatment, was an essential feature of the tests; and, sometimes, the samples were screened into sizes before assaying. Moreover, by taking samples from the amalgamating-pans at varying stages of the process, and then subjecting the filtrates from these samples to chemical analysis; also, by analyzing the particles of amalgam obtained from these periodic samples, some additional light was obtained. Many of the analyses were only qualitative, and on account of the closing down of the mill for lack of ore, the investigations were interrupted before the series of tests was complete. Unfortunately, the notes of this work are not within reach. A few things, however, seemed clear:

1. Iron and mercury are the most important reagents in the pan process.

2. In some cases, the mercury is quickened by the addition of a small quantity of freshly precipitated metallic copper. This is one of the things ultimately resulting from the use of blue vitriol.

3. Salt (sodium chloride) solution serves as a solvent and wash, rather than as a reagent, and is most valuable when hot and concentrated. It helps to keep the mercury clean. As a solvent for silver chloride, it gives metallic reducing agents a better chance to act on mineral in that form.

4. Soluble iron salts, and other secondary products that come from the use of salt and blue vitriol, are of considerable value in the treatment of ores containing silver sulphides.

5. Free acids sometimes assist in the treatment of ores containing native silver sulphides, but are of no benefit with native silver chlorides, and are positively detrimental when the ore contains any lead carbonate or other oxidized lead mineral.

It is not safe to lay down any hard and fast rules, because ore from every mine has its own peculiarities, and numerous unknown factors are introduced locally, the results of which can be determined only by careful analysis, followed by painstaking working-tests. The student of this branch of silver metallurgy, who wishes to save himself much wearisome labor without being led into wrong paths, would do well to consult the works of Percy¹ and Collins.² Dr. Percy has sometimes been called the father of English metallurgical literature. His work in the field of silver metallurgy, although only a chapter in his career, commands our admiration because of the exhaustive attempts to get at fundamental principles. His own experiences, as well as the work of former experimenters, are set down in a way that all may imitate with profit and few will succeed in equaling. In beginning one of his prefaces, he says: "Of all the branches of metallurgy, that of which silver forms the subject is, in my opinion, the most extensive, the most varied, and the most complicated."

¹ *Metallurgy: The art of extracting metals from their ores. Silver and Gold.—Part I.* By John Percy. London, 1880.

² *The Metallurgy of Lead and Silver: Part II.—Silver.* By Henry F. Collins. London, 1900.



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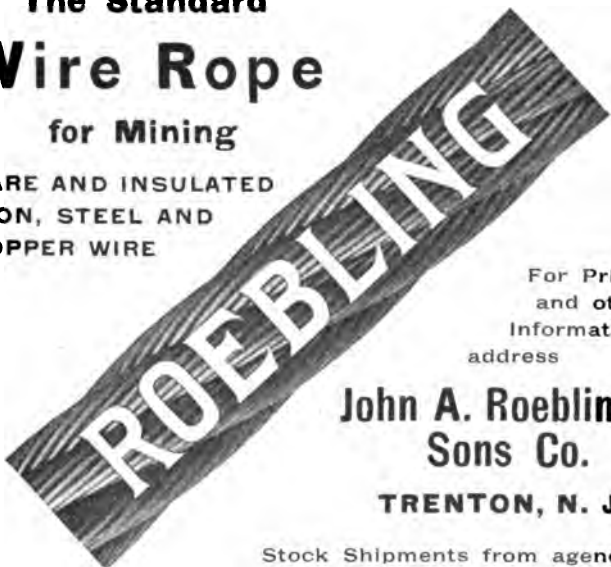
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No. 40

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1910

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SECTION I.—INSTITUTE ANNOUNCEMENTS.

This section contains announcements of general interest to the members of the Institute, but not always of sufficient permanent value to warrant republication in the volumes of the *Transactions*.

SECTION II.—TECHNICAL PAPERS AND DISCUSSIONS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

A detailed list of the papers contained in this section is given in the Table of Contents. They have been so printed and arranged (blank pages being left when necessary) that they can be separately removed for classified filing, or other independent use.

A small stock of separate pamphlets, duplicating the technical papers given in Section II. of this Bulletin, is reserved for those who desire extra copies of any single paper.

Comments or criticisms upon all papers given in this section, whether private corrections of typographical or other errors or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.

All communications concerning the contents of this Bulletin should be addressed to Dr. Joseph Struthers, Assistant Secretary and Editor, 29 W. 39th St., New York, N. Y. (Telephone number 4600 Bryant).

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INSTITUTE ANNOUNCEMENTS.

International Congress for Mining, Metallurgy, Applied Mechanics, and Practical Geology, Düsseldorf, June, 1910.

A full account of the organization of the Congress, including rules of membership, classification of papers, time of presentation, length, etc., will be found in *Bulletin* No. 37, January, 1910.

A recent circular from the Secretary of the Congress, Dr. E. Schroedter, advises that the number of applications for membership up to Feb. 1, 1910, had reached the very satisfactory total of 750, of which one-third was from foreign countries. From this excellent showing at so early a date before the meeting it is reasonable to expect that there will be a large attendance at the meeting.

For the information of members of the Institute who expect to be abroad this summer, and for those who might make the trip if they knew of the many professional, social, and scenic attractions offered in connection with the Congress, a detailed list of the papers to be presented, together with the program of the visits and excursions, is given later in this notice.

The time-limit for application for membership in the Congress, originally set for Mar. 1, 1910, has been extended, and it is requested that those who contemplate attendance and have not yet applied for membership will communicate at once with the Secretary, Dr. E. Schroedter, Düsseldorf, Jacobistrasse 3/5, Prussia.

The official representatives of the Institute at the Congress are Mr. Charles Kirchhoff, Past-President, and Mr. Edward W. Parker, Past-Councilor, who are authorized to express on that occasion the cordial greetings of the Institute to its professional colleagues beyond sea.

I. Provisional Programme.

Saturday, June 18. Opening of the Congress in the "Tonhalle."

Sunday, June 19. Informal meeting of the members of the Congress.

Monday, June 20. Opening ceremony of the Congress. Assembling of the Sections. First Meetings of the Sections. Evening, Reception given by the town of Düsseldorf.

Tuesday, June 21. Meetings of the Sections. Evening, Grand Banquet.

Wednesday, June 22. Meetings of the Sections. Evening, Trip up the Rhine to beyond Duisburg.

Thursday, June 23. Excursions, and Concluding Meeting of the Congress in the "Städtische Saalbau" to Essen, followed by a Garden-Party.

Provisional Programme of the Various Sections :

Section I : Mining.

Bergassessor Adam, Saarbrücken : "The Hydraulic Blasting-Pump and Its Performance."

Consulting Engineer v. Bavier, Düsseldorf : "The Development of Fans and Compressors in the German Mines" (in common with Section III).

Bergassessor Beyling, Gelsenkirchen : "The Optical Investigation of Fire-damp."

Bergwerksdirektor Bruchhausen, Dortmund : "Shaft-Sinking by the Cement Process."

Professor Bruns, Gelsenkirchen : "To What Extent are Infectious Diseases Spread by Mining Operations?"

Bergassessor Döbbelstein, Essen : "Utilization of Low-Grade Fuels."

Geheimer Bergrat Professor Franke, Berlin : "Haulage from the Working-Faces."

Engineer W. E. Garforth, Sheffield : "The British Coal-Dust Experiments."

Direktor Giller, Mülheim-Ruhr : "Compressed-Air Locomotive Haulage in Mines" (in common with Section III).

Engineer Goetze, Bochum . "New Methods in the Construction and Working of Fans and Compressors" (in common with Section III).

Bergassessor Grahn, Bochum : "The Use of Compressed-Air Locks in Sinking."

Professor Haussmann, Aix-la-Chapelle : "New Methods in the Domain of Underground Surveying, including Earth Magnetism and Earthquake Investigation."

Professor Herbst, Aix-la-Chapelle : "On the Development of Coking Process, as Regards the Construction of the Ovens and Improvement of the Mechanical Working Arrangements" (in common with Section II).

Dr. Jüngst, Essen : "Unification of Mining Statistics."

Bergmeister Dr. Kohlmann, Diedenhofen : "The Mining Development of the Minette District."

Bergassessor Kukuk, Bochum : "The Tectonic Conditions of the Lower Rhine-Westphalian Coal-Deposits in View of the Latest Explorations" (in common with Section IV).

Bergassessor Macco, Brühl : "The Laws of Mining Economics, Their Substance and Their Limits" (in common with Section IV).

Engineer Sam Mavor, Glasgow : "Machine Mining of Coal in the Long Wall System."

Oberingenieur Philippi, Berlin : "Electricity in Mining" (in common with Section III).

Dipl.-Bergingenieur Pütz, Kattowitz : "The Present State of the Refuse-Washing Process."

Professor Rau, Aix-la-Chapelle : "Progress in the Domain of the Recovery of Bye-Products of Coke Ovens" (in common with Section II).

Kaiserlicher Rat Schember, Vienna : "Practical Kirving in Coal Mining."
 Engineer Schulze, Essen : "New Methods on the Domain of Mine Pumping"
 (in common with Section III).

Professor Schwemann, Aix-la-Chapelle : "Mine Workings and the Preservation of Timber."

Bergassessor Viebig, Kray : "Use of Reinforced Concrete in Mine Workings."

Direktor Zähringer, Nordhausen : "The Freezing Process and Its Latest Developments."

N. N. : "Bases for the Uniformity of the Testings of Winding Ropes."

N. N. : "Tubbing of Shafts at Great Depths."

Section II : Metallurgy.

A. Section for Practical Metallurgy.

Dr. Blasberg, Dahlhausen : "On the Change in the Composition of Fire-proof Stones."

Hjalmar Braune and Edv. Hubendick, Stockholm : "Production of Tarless Generator-Gases from Bituminous Fuels in the Light of Organic Chemistry."

P. Breuil, Couillet : "Rail Steels."

Steel-Works Manager Esser, Differdingen : "On the Present State of the Converter-Process in Germany."

Geh. Bergrat Professor G. Franke, Berlin : "On the Present State of the Ore-Briquetting and Agglomerating Process in Germany."

"On the Present State of the Open-Hearth Process in Germany."

(a) Direktor R. Genzmer, Julienhütte : "The Pig-Iron-Ore Processes."

(b) Oberingenieur J. Hofmann, Witkowitz : "On Gas Producers"

(c) Oberingenieur Terpitz, Hubertushütte : "On the Use of the Various Kinds of Gas for Working Open-Hearth Furnaces and Their Influence on the Quality of the Products."

(d) Dipl.-Ing. Friedrich, Julienhütte : "Recent Improvements in the Construction of Open-Hearth Furnaces."

Professor Herbst, Aix-la-Chapelle : "On the Development of the Coking Process as Regards the Construction of the Ovens and Improvements of the Mechanical Working Arrangements" (in common with Section I).

Engineer Th. Kautny, Cologne : "On the State of Progress of the Autogenous Welding Processes in Germany."

Oberingenieur Maleyka, Berlin : "Electricity in Metallurgy" (in common with Section III).

Professor Mathesius, Charlottenburg : "A New Method for the Preparation of Iron-Ores."

Oberingenieur Mauritz, Nürnberg : "On the Economy of the Various Ways of Driving Steel-Works Blowing-Engines."

Professor Dr. Neumann, Darmstadt : "On the Present State of Progress of the Electro-Steel Processes in Germany."

Direktor H. Ortmann, Völklingen : "New Methods of Construction of Trains of Rolls Within the Last Decade" (in common with Section III).

Dr.-Ing. J. Puppe, Dortmund : "Results of Recent Investigations in the Domain of Rolling Technics in Germany."

Professor Dr. Rau, Aix-la-Chapelle : "Progress in the Domain of the Recovery of Bye-Products of Coke Ovens" (in common with Section I).

N. N. : "On the Present State of the Question of the Cleaning of Blast-Furnace Gases in Germany."

B. Section for Theoretical Metallurgy.

- Geheimrat Professor Dr. Borchers, Aix-la-Chapelle: "The Procedure in Connection with the Concentration and Refining Operations in the Winning of Copper, Their Acceleration and Simplification by Means of Electric Smelting."
- Dozent Dr. Bornemann, Aix-la-Chapelle: "Electric Conductivity of the Metallic Alloys in the Fluid Condition."
- Dipl.-Ing. Gillhausen, Aix-la-Chapelle: "Heat and Material Balance-Sheet of the Blast-Furnace."
- Professor Dr. Ing. P. Goerens, Aix-la-Chapelle: "On Gases in Technical Qualities of Iron."
- Dr. Grossmann, Berlin: "On the Newer Methods for the Determination of Nickel in Nickel Ores and Nickel Steel."
- Professor Guillet, Paris: (a) "Thermic Treatment of Alloy Steels;" (b) "Some Observations on Cementation from Theoretical and Practical Points of View."
- Dipl.-Ing. Joisten, Aix-la-Chapelle: "Influence of the Thermic Treatment on the Size of Grain of Iron."
- Professor Joseph W. Richards, South Bethlehem, Pa.: (a) "Gruner's Ideal Running of the Blast-Furnace;" (b) "The Advantages of Dried Blast."
- Professor Dr. Ruer, Aix-la-Chapelle: "The System Iron-Nickel."
- Professor Dr. Schenck, Aix-la-Chapelle: "On the Conditions Governing the Reduction and Cementation of Iron."
- Dipl.-Ing. Weyl, Aix-la-Chapelle: "Cementation in a Vacuum."
- Dr. Winter, Bochum: "On the Influence of Galvanizing on the Strength of Wire."
- Geheimrat Professor Dr. Wüst and Dipl.-Ing. Felser, Aix-la-Chapelle: "The Influence of Liquefaction on the Strength of Mild Steel."
- Geheimrat Professor Dr. Wüst, Aix-la-Chapelle: "The Influence of the Heating and Drying of the Blast on the Reactions in the Hearth of the Blast-Furnace."

Section III: Applied Mechanics.

- Consulting Engineer v. Bavier, Düsseldorf: "The Development of Fans and Air-Compressors in German Mines" (in common with Section I).
- Oberingenieur Bernstein, Cologne: "Hydraulic Compressors."
- Works Manager Giller, Mülheim a/Ruhr: "Compressed-Air Locomotive-Haulage in Mines" (in common with Section I).
- Engineer Goetze, Bochum: "New Methods in the Construction and Working of Fans and Compressors" (in common with Section I).
- Engineer Dr. Hoffmann, Bochum: "The Driving of Power Machines."
- Professor Langer, Aix-la-Chapelle: "Recent Experiences in the Working of Gas Engines."
- Oberingenieur Maleyka, Berlin: "Electricity in Metallurgy" (in common with Section II).
- Dipl.-Ing. C. Matschoss, Berlin: "The Position of Mining and Metallurgy in the History of Engineering."
- Direktor H. Ortmann, Völklingen: "New Methods of Construction in Connection with Trains of Rolls During the Last Decade" (in common with Section II).
- Oberingenieur Philippi, Berlin: "Electricity in Mines" (in common with Section II).

- Professor Dr. Ing. h. c. Rateau, Paris: (a) "Installations for the Utilization of Exhaust Steam;" (b) "Turbo-Compressors."
- Direktor Regenbogen, Starkrade: "Turbo-Compressors."
- Engineer Schulze, Essen: "New Methods in the Domain of Mine Pumping" (in common with Section II).
- Dipl.-Ing. Tillmann, Saarbrücken: "Underground Haulage."
- Professor A. Wallichs, Aix-la-Chapelle: "Armour Plates, Their Manufacture and Manipulation."
- Oberingenieur Mauritz, Nürnberg: "On the Economy of the Various Systems of Driving Steel-Works Blowing-Engines" (in common with Section II).
- "Report on the Experimental Trials of Winding Engines," undertaken by the "Verein für die bergbaulichen Interessen," the "Dampfkessel-Überwachungsverein of the Collieries in the Oberbergamtsbezirk Dortmund," and the "Verein deutscher Ingenieure."

Proposed Visits of Inspection of Sections I, II, and III to Works, etc.

Visits of Inspection to important mines, metallurgical works, engineering establishments, and scientific institutions are planned. Negotiations with reference to such are already concluded.

Section IV: Practical Geology.

- Professor Dr. Ch. Barrois, Lille: "The Origin of the Clastiques Coal Deposits and the Erratic Blocks Found in the North of France."
- Geh. Bergrat Professor Dr. Benschlag, Berlin: "Communication on the Iron Supplies of the World."
- Dr. Fliegel, Berlin: "The Tectonics of the Lower Rhine Inlet and Their Importance for the Development of the Lignite Formations."
- Mining Engineer Krahmann, Berlin: "The New Mineral Deposit Policy and Its Problems."
- Professor Dr. Krusch, Berlin: (a) "The Otavi Copper Ore-Deposits from the Genetic and Politico-Economic Points of View;" (b) "The Radium Deposits and the Probable Development of the Radium Market."
- Bergassessor Kukuk, Bochum: "The Tectonic Conditions of the Lower Rhine-Westphalian Coal Deposits in View of the Latest Explorations."
- Reg.-Baumeister a. D. Link, Essen: "The Dams of the Ruhr District with Special Consideration of the Möhne Valley Dam."
- Bergassessor Macco, Cologne: "Mining Economics, Their Substance and Their Limits" (in common with Section I).
- Mine Surveyor Mintrop, Bochum: "On Artificial Earthquakes."
- H. Mortimer-Lamb, Montreal: "The Unique Mineral Resources of Canada."
- Professor Dr. Potonié, Berlin: "The Origin of Coal."
- Geological Engineer Renier, Liège: "The State of Our Knowledge of the General Stratigraphy of the Belgian Coal District."
- Director General Schulz-Briesen, Düsseldorf: "Importance of Practical Geology in Science and Political Economy."
- Geh. Bergrat Professor Dr. Steinmann, Bonn: "On the Combined Ore Veins in the Cordilleras of South America."
- Privat-Dozent Dr. Wegner, Münster: "Underground Water Conditions of the Münster Country."

Additional papers on subjects to be communicated later have been promised by Messrs. Dr. Bärtling, Berlin ; Professor Holz, Aix-la-Chapelle ; Professor Dr. Michael, Berlin ; Professor Dr. Scheibe, Berlin ; Professor Dr. Stille, Hannover ; Mine Surveyor Wachholder, Düsseldorf ; and Dr. Wunstorf, Berlin.

Proposed Excursions and Visits of Inspection of Section IV.

- (a) Geological Excursion (1½ to 2 days) to the Southern edge of the Münster Chalk Basin under the leadership of Professor Dr. Krusch, Kgl. Geologe Dr. Bärtling, and Bergassessor Kukuk.
 1st day-Leader : Professor Dr. Krusch : Continuous Section Through Upper Devonian, Culm, and Poor and Rich Carboniferous Formations, with Ruhr Terraces.
 2nd day-Leader : Dr. Bärtling : Cenomanian, Labiate Chalk and Diluvian Formations.
- (b) Geological half-day excursion in the Lower-Rhine Lignite district of Brühl-Cologne. Leader : Kgl. Geologe Dr. Fliegel.
- (c) Whole-day excursion to the Möhne Valley dam works near Arnsberg. Leader : Kgl. Regierungsbaumeister a. D. Link.
- (d) Half-day excursion to inspect the Geological Museum, the Earthquake Station, and the Magnetic Observatory of the Westphalian Mining Company of Bochum. Leaders : Bergassessor Kukuk and Mine-Surveyor Mintrop.

Excursion to Brussels.

In connection with the Düsseldorf Meetings, the Managers of the Brussels World Exhibition have issued invitations to the members of the Congress to pay a visit to the Exhibition together. The provisional Programme is as follows :

Friday, June 24, Evening: Reception by the Imperial Commissioner in the German Section of the Exhibition.

Saturday, June 25. Inspection of the Exhibition. In the evening : Reception by the Town in the Town Hall or Gala Performance in the "Monnaie."

Sunday, June 26. Inspection of the Exhibition and of the Town. In the evening : Banquet and Fireworks given by the Managers of the Exhibition.

Meetings of Other Societies.

American Institute of Electrical Engineers.—A meeting of the American Institute of Electrical Engineers will be held at San Francisco, Cal., May 5, 6, and 7, 1910.

The meeting will be under the auspices of the High-Tension Transmission Committee. The sessions will be held at the Home Telephone Company's building, 333 Grant Avenue. There will be four professional sessions on the first two days, and a tour of inspection on the third day and several days of the succeeding week. Morning and afternoon sessions will be held on each of the first two days. The following papers will be presented by their respective authors :

The Developed High-Tension Network of a General Power System, by Paul M. Downing, Engineer of Operation and Maintenance, Pacific Gas & Electric Co.

Hydroelectric Developments and Irrigation, by John Coffee Hays, Consulting Engineer, and President, Mt. Whitney Power Co.

Emergency Generating Stations for Service in Connection with Hydroelectric Transmission Plants under Pacific Coast Conditions, by A. M. Hunt, Consulting Engineer and Past-Chairman, San Francisco Section A. I. E. E.

Through the courtesy of the several central California hydroelectric power companies, visits will be made to the more important standby plants and receiving stations in the San Francisco Bay region on Saturday, May 7, and to the transmission-plants and mountain generating-stations the first days of the succeeding week.

The high character of the papers which will be presented at this meeting, as well as the valuable discussion to be expected, should attract a large number of engineers, not only from the Pacific coast, but from other parts of the United States.

The opportunities afforded by the proposed tours for observing high-tension transmission-practice in central California will add greatly to the interest.

The American Society of Mechanical Engineers.—A meeting of the American Society of Mechanical Engineers will be held in Boston, Mass., April 27, 1910, at which meeting Prof. C. M. Allen will present a paper upon The Testing of Water-Wheels after Installation.

Members of the American Institute of Mining Engineers are cordially invited to attend these meetings.

How to Use the "Transactions" of the Institute.

Buy a copy of the Complete Analytical and Alphabetical Index of Volumes I. to XXXV., inclusive.

If you own a full set of the *Transactions*, this Index will make the whole of it instantaneously available without detailed research into each volume separately.

If you do not own such a set, this Index will be even more valuable, for it will show you what particular papers you need to know more about, and perhaps to study. Thus, any person possessing this Index can ascertain at once what has been published in the *Transactions* on a given question, and can learn, by writing to the Secretary, what is its nature, whether it is still to be had in pamphlet form, where it can be consulted in a public library, at what cost it can be copied by hand, etc., etc.

In short, to those who own complete sets of the *Transactions*, this Index will be a great convenience; but to those who do not, it will be a professional necessity.

This volume is an octavo of 706 pages, containing more than 60,000 entries, duly classified with sub-headings, and including abundant cross-references. It has not been stereotyped, and the edition is limited to 1,600 copies. The price of the volume, bound in cloth, is \$5, and bound in half-morocco to match the *Transactions*, \$6. The delivery charges will be paid by the Institute on receipt of the above price.

Hydrographic Chart.

Owing to the great value to hydrographers of the chart contained in the paper, A Graphic Solution of Kutter's Formula, by L. I. Hewes and Joseph W. Roe (*Bulletin No. 29*, May, 1909, p. 454), a special edition for office or field use has been printed on durable cloth. Copies of this separate chart may be obtained, at a cost of 50 cents each, on application to the office of the Secretary of the Institute.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

AMERICAN INSTITUTE OF MINING ENGINEERS.

UNITED ENGINEERING SOCIETY.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays, from September 1 to June 30, and from 9 A.M. to 6 P.M. during July and August.

RULES.

For the protection and convenience of members, the following rules have been adopted :

The Secretary of each Society will, upon application, issue to any member of his Society in good standing a personal, non-transferable card, entitling him to the use of the Libraries in the alcoves of the Reading-Room. This card must be signed by the person receiving it, and surrendered at the desk at the time of its presentation. At every visit he must identify himself by signing his name in the registry.

The first two alcoves are free to all; and admission to the inside alcoves is given only upon proper introduction.

The above rules apply to all persons except officers of the three Societies, personally known as such to the librarians.

The librarians are not permitted to lend to any person any catalogued pamphlet or volume, unless authorized in writing so to do by the Secretary or Chairman of the Library Committee of the Society to which the pamphlet or volume belongs.

Any person discovering a mutilation or defect in any book of the libraries is requested to report it to the librarian on duty.

Library Accessions.

Mar. 1 to Apr. 1, 1910.

[Copies of the list of additions to the Libraries of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers can be obtained on application to the Secretary of the American Institute of Mining Engineers.]

- AMERICAN MUSEUM OF NATURAL HISTORY. Bulletin. Vol. 27, 1910. New York, 1910. (Exchange.)
- ANALYSES OF ROCKS AND MINERALS FROM THE LABORATORY OF THE UNITED STATES GEOLOGICAL SURVEY, 1880-1908. (Bulletin No. 419, U. S. Geological Survey.) Tabulated by F. W. Clarke. Washington, 1910. (Exchange.)
- BALLISTIC ELECTRO-DYNAMOMETER METHOD OF MEASURING HYSTERESIS LOSS IN IRON. (Bulletin No. 1, Engineering Experiment Station, University of Kansas.) By M. E. Rice and Burton McCollom. Lawrence, 1909. (Gift.)
- BELGIUM. DE L'INTERIEUR ET DE L'AGRICULTURE MINISTÈRE. Rapport sur la situation de l'Industrie minérale et métallurgique dans la Province, 1908. Frameries, 1909. (Gift.)
- BERG UND HÜTTENWERKEN IM KÖNIGREICHE SACHSEN. Jahrbuch, 1909. Freiberg, 1909. (Exchange.)
- CANADA. MINES DEPARTMENT. Geological Reconnaissance of the Region Traversed by the National Transcontinental Railway between Lake Nipigon and Clay Lake, Ontario. By W. H. Collins. Ottawa, 1909. (Exchange.)
- Iron-Ore Deposits of Vancouver and Texada Islands, British Columbia. By E. Lindeman. Ottawa, 1909. (Exchange.)
- Joint Report on the Bituminous or Oil Shales of New Brunswick and Nova Scotia; also on the Oil Shale Industry of Scotland. By R. W. Ellis. Ottawa, 1910. (Exchange.)
- Preliminary Report on the Mineral Production of Canada, 1909. Ottawa, 1910. (Exchange.)
- Report on the Investigation of an Electric Shaft Furnace, Domnarfvet. Sweden. Ed. 2. By Eugene Haanel. Ottawa, 1909. (Exchange.)
- COMMERCIAL VALUE OF THE OIL SHALES OF EASTERN CANADA. By B. W. Ellis. (Advance paper, Mining Society of Nova Scotia. Journal, Vol. 15.) Halifax, 1910. (Exchange.)
- COMMERCIALISM AND JOURNALISM. By Hamilton Holt. Boston-New York, 1909. (Gift of University of California.)
- CONFLICT BETWEEN PRIVATE MONOPOLY AND GOOD CITIZENSHIP. By J. G. Brooks. Boston-New York, 1909. (Gift of University of California.)
- ELECTRIC HAULAGE IN No. 5 COLLIERY. By R. Robertson. (Advance paper, Mining Society of Nova Scotia. Journal, Vol. 15.) Halifax, 1910. (Exchange.)
- ENGINEERING STANDARDS COMMITTEE. Third Report of the Locomotive Committee on Standard Locomotives for Indian Railways. (No. 50.) London, 1910. (Exchange.)
- FIELD MUSEUM OF NATURAL HISTORY. Annual Report of the Director, 1909. Chicago, 1910. (Exchange.)
- GEOLOGY OF THE AUBURN-GENOA QUADRANGLES, (Bulletin No 137, New York State Museum. By D. D. Luther. Albany, 1910. (Exchange.)
- HANDELSPREISE FÜR KOHLE UND EISEN. (Reprint, *Stahl und Eisen*, No. 17, 1910.) N. p., n. d. (Exchange.)

- HAULAGE SYSTEM AT NOS. 3 AND 4 COLLIERIES. By John Johnston. (Advance paper, Mining Society of Nova Scotia. Journal, Vol. 15.) Halifax, 1910. (Exchange.)
- INSTITUTE OF METALS. Journal. Vol. 2. London, 1909. (Exchange.)
- INSURANCE LAWS OF PENNSYLVANIA, 1909. Harrisburg, 1909. (Exchange.)
- IOWA GEOLOGICAL SURVEY. Annual Report, Vol. 19, 1908. Des Moines, 1909. (Exchange.)
- IRON-ORE DEPOSITS OF VANCOUVER AND TEXADA ISLANDS, BRITISH COLUMBIA. By E. Lindeman. Ottawa, 1910. (Exchange.)
- JOHN CREBAR LIBRARY. List of Current Medical Periodicals and Allied Serials, Dec. 1909. Chicago, 1910. (Exchange.)
- LAVERIE MAGNETICHE DI MONTEPONI. By E. Ferraris. Iglesias, 1910. (Estratto dal *Bollettino* No. 2, Anno XV., Associazione Mineraria Sarsa. (Gift of Author.)
- MAGNETISCHE ERZAUFBEREITUNG VON MONTEPONI. By E. Ferraris. N. p., n. d. (Spearatabdruck aus der *Oesterreichischen Zeitschrift für Berg-u. Huttenwesen*, 1909. (Gift of Author.)
- MAP OF THE EASTERN OREGON GOLD-FIELD. By D. W. C. Nelson. Baker City, Ore., n. d. (Gift of Author.)

[SECRETARY'S NOTE.—This map is a piece of honest and effective work by a member of the Institute, who has compiled it partly from his own surveys and partly from government records. It shows the streams, highways, railroads, towns, and working mines, with the altitudes of the more important points. The area covered is 42 by 72 miles in extent (covering, probably, the whole of the Eastern Oregon gold-field); and the map itself, made on a scale of one inch to the mile, measures 46 by 76 inches. It is printed on cloth-fiber, in black lines upon a white ground, and will be sent by Mr. Nelson, express-paid, in a paste-board tube, on receipt of \$5.50. He announces also that, if the map is not satisfactory, it may be returned within five days after its receipt, and the price will be refunded. But this notice is superfluous; since no one who does not need a map of the Eastern Oregon gold-field will be likely to order this one, while any one who does need such a map will find it to be all that it is asserted to be. The Secretary's notices are not advertisements; but when a member of the Institute has patiently performed a work like this, I think that he is entitled to have it recognized, and that his fellow-members are entitled to know how, and at what cost, they can avail themselves of the result of his labor.—R. W. R.]

- MINERAL RESOURCES OF THE UNITED STATES, 1908. Pts. 1-2. Washington, 1909. (Exchange.)
- MINING INDUSTRY OF IDAHO. Annual Report, 11th. Boise, 1909. (Gift of Inspector of Mines of Idaho.)
- MINING SOCIETY OF NOVA SCOTIA. Journal. Vol. 14. Halifax, 1910. (Exchange.)
- NEW ZEALAND OFFICIAL YEAR-BOOK, 1909. Wellington, 1909. (Gift of the Registrar-General of New Zealand.)
- OLD GRANITES OF THE TRANSVAAL AND SOUTH AND CENTRAL AFRICA. By C. B. Horwood and A. Wade. (Extracted from *Geological Magazine*, Oct.-Dec., 1909. London, n. d. (Gift of C. B. Horwood.)
- PALISADE DIABASE OF NEW JERSEY. By J. V. Lewis. (From *American Journal of Science*, Vol. 26.) N. p., n. d. (Exchange.)

PEAT: ITS USE AND MANUFACTURE. By P. R. Björling and F. T. Gissing. London, C. Griffin & Co., 1907. (Gift of J. B. Lippincott Co.)

COMMERCIAL PEAT: ITS USES AND POSSIBILITIES. By F. T. Gissing. London, 1910. (Gift of J. B. Lippincott Co.)

[**SECRETARY'S NOTE.**—These two books belong together; but of the two authors to whom the late Sir Clement Le Neve Foster originally suggested the preparation of the treatise, Mr. P. R. Björling died before the issue of the first of the two. The responsibility and the credit of both may therefore be given with justice to the survivor, Mr. Gissing, though without detracting from the merit of his former co-worker. The selection of either by Clement Le Neve Foster is a guaranty of the value of the work, which an inspection of it amply confirms.]

In these days of ardent (though not always intelligent) interest in the conservation of natural resources—especially those of fuel—the revelation and establishment of new resources is as pertinent as the hoarding of those better known and more highly rated; and the economic importance of peat, often prematurely emphasized heretofore, is fast approaching (if it have not already reached, in some localities) the psychological moment when it will command wide-spread attention. During many years the utilization of peat has been quietly increasing, both in extent and in scientific knowledge; and these two books will supply to engineers a timely summary of both branches of the subject. Taken together, they furnish a complete statement of the formation, growth, distribution, and uses of peat, with descriptions of the methods and machines involved, which it would be difficult to find so collected and compacted anywhere else. Those who have heretofore regarded peat as merely an inferior kind of fuel will be surprised and enlightened to learn its value for the production of alcohol, ammonia, and nitrates; as a material for the manufacture of paper, etc. Even in the department of simple fuel, its economic efficiency in the form of fuel-gas claims wider recognition than it has yet received. The professional world is indebted to Mr. Gissing for this useful and helpful statement of a subject so important.—R. W. R.]

PENNSYLVANIA. AGRICULTURE DEPARTMENT. Annual Report, 14th, 1908. Harrisburg, 1908. (Exchange.)

—— **INSURANCE COMMISSIONER.** Annual Report, 36th, 1908. Harrisburg, 1909. (Exchange.)

—— **INTERNAL AFFAIRS DEPARTMENT.** Annual Report of the Secretary. Pt. III., Vol. 36, 1908. Harrisburg, 1909. (Exchange.)

PETROGRAPHY OF THE NEWARK IGNEOUS ROCKS OF NEW JERSEY. By J. V. Lewis. (From Annual Report of the State Geologist for 1907.) Trenton, 1908. (Exchange.)

PHELPS, DODGE & Co. Annual Report, 1909. New York, 1909. (Gift of Phelps, Dodge & Co.)

PHYSIOGRAPHY OF THE ST. LOUIS AREA. (Bulletin No. 12, Illinois State Geological Survey.) By N. M. Fenneman. Urbana, 1909. (Exchange.)

PRELIMINARY REPORT ON THE MINERAL PRODUCTION OF CANADA, 1909. Ottawa, 1910. (Exchange.)

RECONNAISSANCE OF SOME MINING CAMPS IN ELKO, LANDER, AND EUREKA COUNTIES, NEVADA. (Bulletin No. 408, U. S. Geological Survey.) By W. H. Emmons. Washington, 1910. (Exchange.)

ROYAL SOCIETY OF NEW SOUTH WALES. Journal and Proceedings. Vols. 42- and 43, Pt. 1. Sydney, 1908-1909. (Exchange.)

SMULL'S LEGISLATIVE HAND-BOOK AND MANUAL OF THE STATE OF PENNSYLVANIA, 1909. Harrisburg, 1909. (Exchange.)

- SOCIEDAD GEOLOGICA MEXICANA. Boletin. Tomo 5. Mexico, 1909. (Exchange.)
- SOCIÉTÉ DE L'INDUSTRIE MINÉRALE. Bulletin. Vols. 1-5; Ser. 2, Vols. 1-7. Paris, 1855-1869, 1872-1878. (Purchase.)
- Tables générales des matières. Vols. 1-15. Saint Etienne, 1871. ((Purchase.)
- Atlas. Vols. 1-55; Ser. 2, Vols. 1-4, 5, Nos. 2-3; Vol. 6; Vol. 7, Nos. 1-3. Saint Etienne, 1855-1869, 1872-1878. (Purchase.)
- SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS. List of Members, 1910. Brooklyn, n. d. (Gift of Society of Naval Architects, etc.)
- STATUTES AT LARGE OF PENNSYLVANIA FROM 1682-1801. Vol. 13, 1787-1890. Harrisburg, 1908. (Exchange.)
- TABLES RELATING TO THE OUTPUT OF COAL AND OTHER MINERALS AND THE NUMBER OF PERSONS EMPLOYED AT MINES WORKED UNDER THE COAL AND METALLIFEROUS MINES REGULATION ACTS, 1909. (Great Britain. Mines and Quarries: General Reports and Statistics.) London, 1910. (Exchange.)
- TEMISKAMING AND NORTHERN ONTARIO RAILWAY COMMISSION. Report on Mining and Power Development, 1909. By A. A. Cole. Toronto, 1910. (Gift of J. L. Englehart.)
- THAYER SCHOOL OF CIVIL ENGINEERING. Annual, 1909. N. p., 1909. (Gift.)
- TRANSVAAL MINES DEPARTMENT. Annual Report of the Government Mining Engineer, 1909. Pretoria, 1909. (Exchange.)
- TUNGSTEN: MOOSE RIVER SCHEELITE VEINS. By A. A. Hayward. (Advance paper, Mining Society of Nova Scotia. Journal, Vol. 15.) Halifax, 1910. (Exchange.)
- U. S. BUREAU OF STEAM ENGINEERING. Annual Report, 1907, 1908. Washington, 1907, 1908. (Gift.)
- U. S. COAST AND GEODETIC SURVEY. Report of the Superintendent, 1908-1909. Washington, 1909. (Exchange.)
- U. S. MINT. Report of Director of the Mint, 1908. Washington, 1910. (Exchange.)
- USE OF COKE OVEN GAS AS FUEL. By T. J. Brown. (Advance paper, Mining Society of Nova Scotia. Journal, Vol. 15.) Halifax, 1910. (Exchange.)

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- DONEGAN & SWIFT, New York, N. Y. Clinker-crushing shaking grate; steam-furnace blower; grates for boiler-furnaces. 32 pages.
- GENERAL ELECTRIC Co., Schenectady, N. Y.
- Price-List of G. E. Tantalum incandescent lamps. 5 pages.
- November, 1909, Index to G. E. Bulletins. 9 pages.
- Supplement No. 2. Supplement to General Supply Catalogue No. 4645. 22 pages.
- JEFFREY MANUFACTURING Co., Columbus, O.
- Booklet No. 35. Jeffrey belt conveyors. 24 pages.
- Booklet No. 36. Jeffrey spiral conveyors. 20 pages.
- Program of the Jeffrey sales convention of 1910. (Mining Department.) 16 pages.
- J. GEO. LEYNER ENGINEERING WORKS Co., Littleton, Colo.
- Bulletin No. 1012 of the Drill Department; Reprint: *Tunnel Driving in Colorado*. 8 pages.
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- PULLMAN AUTOMATIC VENTILATOR MFG. Co., York, Pa. Pullman ventilating-cowl for buildings. 1 page.
- SCHOEN-JACKSON Co., Media, Pa. Flexible metal tubing and connections for pressures up to 4,000 pounds from steel, brass, copper, for steam, gas, oil, and conduits. 15 pages.
- SOCIÉTÉ DES HAUTS FOURNEAUX ET FONDERIES, Pont-a-Mousson, France. Handbook containing tables of dimensions used in manufacturing iron pipes, joints, etc., and useful information on molds, pumps, pipes, sewer-covers, etc. 230 pages.
- STROMBERG-CARLSON TELEPHONE MFG. Co., Rochester, N. Y. Bulletin No. 1000. Mine telephones of different types. 10 pages.
- TERRY CORE DRILL Co., New York, N. Y. Catalogue of core-drills for prospecting, testing, blasting, etc. 60 pages.

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MEMBERSHIP.

NEW MEMBERS.

The following list comprises the names of those persons elected as members who accepted election during the month of March, 1910:

Members.

Christopher Bruns, Jr.,	Cumanayagua, Santa Clara, Cuba.
William W. Charles,	Tonapah, Nev.
Arthur O. Christensen,	Sombrerete, Zacatecas, Mexico.
Malcolm M. Galbraith,	Amboy, Cal.
Charles B. Hollis,	Randolph, Vt.
Benzo Katsura,	New York, N. Y.
J. Wilfrid Newbery,	Kalgoorlie, Western Australia.
Benjamin G. Patterson,	Mt. Morgan, Queensland, Australia.
Walter I. Phillips,	Cheyenne, Wyo.
James H. Polhemus,	Cartersville, Mo.
Irving L. Ryder,	San José, Cal.
Alexander Sharp,	Orient, Wash.
Hedley V. Smythe,	Bay of Islands, Newfoundland, Canada.
W. Rogers Wade,	Tyrone, N. M.

CANDIDATES FOR MEMBERSHIP.

The following persons have been proposed for election as members of the Institute during the month of March, 1910. Their names are published for the information of members and associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or unfavorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Council, which has the power of final election.

Members.

J. F. Austin,	Monterey, Mexico.
Z. S. Beyl,	San Rafael, Argentine Republic, S. A.
Edwin Snow Boalich,	Searchlight, Nev.
John W. Boileau,	Pittsburg, Pa.
Edward Haviland Coxe,	Birmingham, Ala.

William Neville Cummins,	Worth, W. Va.
Benjamin F. C. Haanel,	Ottawa, Canada.
William W. Hearne,	Philadelphia, Pa.
Jules Labarthe,	Trail, B. C., Canada.
Nathan Oliver Lawton,	Miami, Ariz.
Bertie Harcourt Moore,	Kalgoorlie, Western Australia.
Walter Leonard Morrison,	Brooklyn, N. Y.
Robert Lewis Parrish,	Covington, Va.
Theodore H. Proske,	Denver, Colo.
Ludwig Rose,	New York, N. Y.
Charles C. Selbie,	South Pasadena, Cal.
Oscar Simmersbach,	Breslau, Germany.
Lyon Smith,	Cortez, Nev.
Maxwell Stevenson, Jr.,	Philadelphia, Pa.
Bruno Thomas,	Seattle, Wash.
Frank Leonard Torres,	Monterey, Mexico.
Kisaburo Yamaguchi,	Tokyo, Japan.

CHANGES OF ADDRESS OF MEMBERS.

The following changes of address of members have been received at the Secretary's office during the month of March, 1910. This list, together with the lists published in *Bulletin Nos. 38, February, and 39, March, 1910*, therefore, supplements the annual list of members corrected to Jan. 1, 1910, and brings it up to the date of Apr. 1, 1910. The names of members who have accepted election during the month (new members) are printed in *italics*.

ANDERSEN, CARL.....	Care Johnnie Min. & Mill Co., Johnnie, Nye Co., Nev.
ANDERSON, R. WILSON.....	403 Minnequa Ave., Pueblo, Colo.
ARMSTRONG, JOHN O.....	Lloyd Copper Co., Ltd., Burrage, N. S. W., Aust.
ASHMORE, E. P.....	P. O. Box 1070, Cobalt, Ont., Canada.
BARCLAY, THOMAS H.....	Casilla 447, Santiago, Chile, So. Am.
BOYD, AUGUSTUS W.....	519 Madison Ave., Spokane, Wash.
BRADLEE, DUDLEY H., Jr.....	18 Forest St., Medford, Mass.
BRADSHAW, FREDERICK, Genl. Supt.,	Tonopah-Belmont Development Co.,
	Tonopah, Nev.
BROAD, WALLACE.....	Changsha, Hunan Prov., China.
BROWN, ALFRED.....	"Ilfracombe," Dover St., Malvern, So. Australia.
BROWN, FREDERICK C.....	1217 N. 9th St., Boise, Idaho.
BROWN, HARVEY S.....	310 N. 6th St., Victor, Colo.
BROWN, JOSEPH.....	Ozark Smelting & Mining Co., Kelly, N. M.
*Bruna, Christopher L., Jr., Min. Engr.,	Mina Carlota, Cumanayagua,
	Santa Clara, Cuba. '10.
BUELL, LLOYD T.....	Care New Cornelia Copper Co., Gila Bend, Ariz.
BULKLEY, FRANK.....	850 Equitable Bldg., Denver, Colo.
BULLEN, JAMES.....	Trewavas, Newtown, Cross Keys, near Newport, England.
CARHART, WINFIELD S.....	1420 Court Pl., Denver, Colo.

- CATES, LOUIS S....Care Utah Copper Co., McCornick Block, Salt Lake City, Utah.
**Charles, William W.*, Comptroller, Tonopah Mining Co., of Nevada,
 Tonopah, Nev. '10.
**Christensen, Arthur O.*, Mine Supt.....Sombrerete, Zac., Mexico. '10.
 COLCORD, FRANK F., Care U. S. Metals Refining Co., 42 Broadway,
 New York, N. Y.
 COLLBRAN, ARTHUR H., Genl. Mgr., Seoul Min. Co., Care Susan Mine,
 Pyeng Yang, Korea.
 COLLINS, FRANCIS W.....554 W. 181st St., New York, N. Y.
 COOKE, HENRY M. A., Supt., Balaghat Gold Mining Co., Ltd.,
 Coromandel P. O., Kolar Gold Field, So. India.
 CORKILL, FREDERICK.....2611 Ashby Ave., Berkeley, Cal.
 COX, THOMAS.....568 29th St., Oakland, Cal.
 DE ARMOND, CHARLES F., Care Crown Mines, Ltd., Box 158,
 Fordsburg, Transvaal, So. Africa.
 DERBY, HENRY S., Scty. and Mgr., Chicago Exploration Co.,
 757 Railway Exchange, Chicago, Ill.
 DISSINGER, EARL.....Sevier Mine, Sevier, Utah.
 DIXON, ALEXANDER G.....Care Fresno Mining Co., Fresno, Zac., Mexico.
 DOUGLASS, ROSE E.....Care Braden Copper Co., Rancagua, Chile, So. Am.
 DUFFIELD, MORSE F.....416 Felt Bldg., Salt Lake City, Utah.
 DUGGAN, GEORGE H., Care Dominion Bridge Co., Lachine Locks,
 Prov. Quebec, Canada.
 ELLAM, A. SPENCER.....Axim, Gold Coast Colony, West Africa.
 EMMONS, WILLIAM H.....Care U. S. Geological Survey, Washington, D. C.
 EMRICH, HORACE H., Care Copper Refinery, Kyshtim Mining Works,
 Kyshtim, Govt. of Perm, Russia.
 ENGLISH, NORRIS.....821 Mills Bldg., San Francisco, Cal.
 EVANS, GEORGE W., Washington Geological Survey, University Sta.,
 Seattle, Wash.
 EYE, CLYDE M.....Aroroy, Masbate, P. I.
 FOGH, H. P.....1403 Howell St., Seattle, Wash.
 FRANK, ALBERT.....Esperanza Mining Co., El Oro, Mex., Mexico.
 FREYMUTH, WILLIAM A.....P. O. Box 116, Rangoon, Burma.
**Galbraith, Malcolm M.*, Min. Engr., Orange Blossom Extension Mining
 & Milling Co., Amboy, Cal. '09.
 GREGSON, WILLIAM H.....Instructed to hold all mail.
 GUNN, GEORGE E., Prest. and Mgr., Gunn-Thompson Co.,
 205-6 Newhouse Bldg., Salt Lake City, Utah.
 HAND, CARLTON H.....1934 Norwood St., Los Angeles, Cal.
 HANKS, ABBOT A.....630 Sacramento St., San Francisco, Cal.
 HENRY, JOHN L.....76 Laurel St., Oakland, Cal.
 HODGE, WALTER R.....Bodie, Okanogan Co., Wash.
 HOLBROOK, ELMER A.....61 Clinton St., Fitchburg, Mass.
**Hollis, Charles B.*, Supt., Eastern Talc Co.....Box 489, Randolph, Vt. '10.
 HOLLAND, L. F. S., Smuggler-Union Mining Co.....Smuggler, Colo.
 HUGHES, HUGH.....Beachvale, Bearsden, near Glasgow, Scotland.
 JEFFS, LEWIS A.....416 Felt Bldg., Salt Lake City, Utah.
 JOHNSON, ALEXANDER T.....634 So. Bonnie Brae St., Los Angeles, Cal.
 KAMIYAMA, TATSUZO, Inspector of Mining Bureau.....Tokyo, Japan.
**Katsura, Benzo*, Prof. of Met., Imperial Tokyo Univ., Care Takata & Co.,
 50 Church St., New York, N. Y. '09.

SOEST, WALTER E.....	Care Foreign Club, Chihuahua, Mexico.
STACPOOLE, ADAM R.....	Instructed to hold all mail.
STEPHEN, ALFRED E.....	Webbs Ave., Ashfield, Sydney, N. S. W., Australia.
STEWART, HOWARD R.....	11 Campau Bldg., Detroit, Mich.
STRAW, CHARLES A.....	Lansford, Pa.
TAYLOR, WILLIAM W., Vice-Prest. and Genl. Mgr.,	Oriskany Ore & Iron Corp., Iron Gate, Va.
THOMSON, ROBERT W.....	Stewart, Portland Canal, B. C., Canada.
THURSTON, E. COPPÉE.....	30 Church St., New York, N. Y.
TRERISE, JOSIAH H.....	Copperopolis, Calaveras Co., Cal.
TUCKER, ALBERT W., Mgr., Gold Hill Consolidated Co., and Cons. Engr.,	Union Copper Mines Co., Gold Hill, N. C.
UNDERWOOD, A. J.....	1103 Story Bldg., Los Angeles, Cal.
VIGEON, E. C., United Rhodesia Gold Fields, Ltd., P. O. Box 94,	Salisbury, Rhodesia, So. Africa
* Wade, W. Rogers, Min. Engr.....	Tyrone, N. M. '10.
WASHBURN, CHESTER W.....	Care U. S. Geological Survey, Washington, D. C.
WELLS, FRANK B.....	Care Midas Gold Mining Co., Knob, Shasta Co., Cal.
WELLS, JAMES S. C.....	879 West End Ave., New York, N. Y.
WENSTROM, OLOF.....	84 State St., Boston, Mass.
WICKES, L. WEBSTER.....	818 Story Bldg., Los Angeles, Cal.
WILCOX, GEORGE...Care W. Ames & Co., 312 Washington St., Jersey City, N. J.	
WILDING, JAMES, JR., Care Wilding & Keller, Apartado 134,	Parral, Chib., Mexico.
WOAKES, ERNEST P.....	88 Fellows Road, London, N. W., England.
YUNG, MORRISON B., Care Jun Wah Co., 313 Des Voeux Road, Hong Kong, China.	

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address on Records, from which Mail has been Returned.
Alexander, George E.,	Sparta, Ore.
Badger, Harry S.,	Goldboro, N. S., Canada.
Bartoccini, Astolfo,	214 E. 90th St., New York, N. Y.
Bassett, Thomas B.,	Cumpas, Sonora, Mexico.
Batchelder, Joseph F.,	54 1st St., Portland, Ore.
Bellam, Henry L.,	Reno, Nev.
Bouchelle, James F.,	22 Duncan Ave., Jersey City, N. J.
Brown, Frank H.,	Coppermount, Alaska.
Campa, Jose,	Mexico City, Mexico.
Cragoe, A. Spencer,	Vencedora, Mexico.
Daniel, Mark,	United Elkhorn Mines, Baker City, Ore.
Dickson, George H.,	Lethbridge, Alberta, Canada.
Donnewald, Albert H.,	3709 Finney Ave., St. Louis, Mo.
Dougherty, Clarence E.,	41 Wall St., New York, N. Y.
Downs, M. E.,	25 Broad St., New York, N. Y.
Ekberg, Benjamin P.,	Johannesburg, Transvaal, So. Africa.
Field, Wilfrid B.,	Mexico City, Mexico.
Fitch, Frank,	Black Mt. Min. Co., Magdalena, Mexico.
Foster, Lewis E.,	Utah Copper Co., Garfield, Utah.
Gaines, Ambrose P.,	Dayton Coal & Iron Co., Dayton, Tenn.
Gee, Emerson,	Reno, Nev.
Geppert, Richard M.,	Ray, Ariz.

Hirschberg, Max R.,	343 St. Nicholas Ave., New York, N. Y.
Hunt, Thatcher R.,	Iron Mt., via Keswick, Cal.
Jewett, Eliot C.,	2918 Morgan St., St. Louis, Mo.
Kow, Tong Sing,	Shanghai, China.
McCan, E. K.,	Braden Copper Co., Graneros, Chile, S. A.
McGregor, J. Murray,	3 Minanciho, Ushigome, Tokyo, Japan.
Mildon, Reginald B.,	Nacozari, Son., Mexico.
Moulton, Herbert G.,	Cobalt, Ont., Canada.
Muir, Thomas K.,	Portland, Ore.
Perkins, Walter G.,	McGill, Nev.
Piper, John W. H.,	Buenos Ayres, Argentine Rep., S. A.
Potter, J. A.,	41 W. 124th St., New York, N. Y.
Sandifer, Harmer C.,	El Oro, Mexico.
Scott, Winfield G.,	Long Beach, Cal.
Skelding, Joseph F.,	Embreeville, Tenn.
Thomas, Richard A.,	43 Wall St., New York, N. Y.
Weddle, Joseph H.,	San Juancito, Honduras, C. A.
Wilson, Odell,	Shingle, Cal.
Wolfe, Burton L.,	Ely, Nev.
Yates, Edwin F.,	P. O. Box 25, Rawhide, Nev.
Young, William,	Kenora, Ont., Canada.

NECROLOGY.

The deaths of the following members have been reported to the Secretary's office during the month of March, 1910:

Date of Election.	Name.	Date of Decease.
1899.	*Frank J. Campbell,	March 6, 1910,
1907.	*Francis V. Drake,	_____
1879.	*Paul A. Fusz,	February 16, 1910.
1906.	*John C. Sevier,	November 11, 1909.
1897.	*Herbert S. Stark,	February 18, 1910.

BIOGRAPHICAL NOTICES.

Frank James Campbell was born 1854 in Niagara County, New York, and went to Colorado for his health in 1878. He settled first at Cañon City, where he remained for two years, in the employ of a firm of hardware-merchants. Removing to Buena Vista, he established there, in the same line of business, a house which became very successful, owning and operating a chain of stores in that part of Colorado. About 1886, Mr. Campbell and his brother-in-law, Guilford S. Wood, engaged as contractors in railroad-building. They constructed portions of the Colorado Midland, the Utah Northern, and the Great Northern in Montana; but when the panic of 1893 caused a

suspension of such undertakings, they returned to Denver, where Mr. Campbell continued to reside until his death, although his many business undertakings took him often away from home. Thus in 1893, he went to Cripple Creek, where he took an active part in the organization of the Vindicator Consolidated Gold Mining Co. in 1894. Of this company he became and remained for the rest of his life the general manager. He was at one time President of the Eagle Ore Co., operating the Eagle sampling-works at Victor, and also an officer of the Amity Gold Co., in the San Juan region, and President of the Western Alkali Co., Green River, Wyoming.

During the labor-troubles of 1904 and following years, Mr. Campbell, though not actively "on the firing-line," was unwavering in his support of law and order against the tyranny and violence of the Western Federation of Miners. At about the beginning of that period, he purchased several mining properties in Goldfield, Nev., and, shortly after, began the organization of what is now known as the Nevada-California Power Co., a corporation which has invested several millions of dollars in a hydro-electric plant supplying power to the principal mining camps of Nevada (Goldfield, Tonapah, Rhyolite, Silver Peak, and Round Mountain). Of this company, he was the first President; and, resigning that position in 1907 after three years' service, he was re-elected to it in February last.

It was during a visit to Goldfield in 1905 that Mr. Campbell was made to feel the hostility of the Western Federation of Miners, which dominated that camp. He was attacked at night by two men, one of whom knocked him down with a gun, and the other shot at him, but fortunately missed him.

Mr. Campbell was a man of calm courage, wise foresight, and great executive ability, combined with integrity, public spirit and private generosity. He was greatly esteemed by the good citizens of every community in which he resided or possessed business interests; and his personal character enabled him to win the support of others for the great undertakings which he planned. As a correspondent in Cripple Creek says: "Mr. Campbell's companies have always been the first to aid in any public work, whether it were drainage-tunnels or the Young Men's Christian Association." He became a member of the Institute in 1899.

Mr. Campbell's death (from double pneumonia) was sudden and unexpected. He had just returned in good health from a trip to Florida, when he was stricken, February 24, by this terrible disease. But on the 6th of March he was supposed to be convalescent, when he began to grow worse, and, rapidly failing, died that evening.

Robert Prewitt Coleman was born Feb. 13, 1880, at Baltimore, Md. His youth was spent in Colorado, where he naturally adopted the profession of his father, a mining engineer of distinction. In 1900 he was for a short period time-keeper at the Highland Boy mine, Bingham, Utah. In the autumn of 1901 he served as assistant to V. P. Strange, U. S. Deputy Mineral Surveyor, Salt Lake City; and in August, 1902, he was engaged upon surveys for the Denver, Northern and Pacific railway. But these temporary occupations appear to have occupied his vacations as a student in the Colorado School of Mines, from which he was graduated in 1903. Thus doubly equipped by school-training and field-practice, he began at once to assist his father in the examination of mines and mineral lands in the United States and Mexico. Having joined the Institute as an Associate, in 1903, while a student at Golden, Colo., he was made a member in 1904, after his graduation. For the four years following, the frequent changes of his address upon the books of the Institute, ranging from Wyoming to Mexico, Arizona, California, and Utah, bear witness to the extent and variety of his field-work. At the time of his death, he was the assistant of Mr. Henry Krumb, a member of the Institute, having his headquarters as a consulting engineer at Salt Lake City. It was apparently in this capacity that he was called to Arizona, in the temporary service of the Ray Consolidated Mining Co. The following paragraph from the *Engineering and Mining Journal* of Feb. 12, 1910, narrates the story of his tragic and untimely death:

"On Feb. 6, an automobile going from Kelvin, Ariz., to the Ray copper mines, ran close to a heavy charge of dynamite, the fuse of which had just been lighted. The explosion of the charge shattered the car and killed the six passengers, who were R. P. Coleman, of Salt Lake City; W. H. Freeland and Walter C. French (mining engineers), and A. S. Bieber, J. C. Griffin and J. B. Joyce (civil engineers). The motorman, who was also killed, had been warned, but probably supposed he could pass before the charge exploded."

This story furnishes another element in the long and continuous series which clouds with sorrow my continuous work as the chronicler of the havoc wrought by death in the ranks of our members. Not only must I record the departure, one after another, of the old men who were once young with me, but every year so many youthful and promising lives are cut short, that it seems to me sometimes as if I had no other function than that of expressing futile lamentations in the face of a merciless Fate. In this instance, I can hardly make the tragedy a text for warnings of caution to mining engineers exclusively. The terrible catastrophe which killed six young engineers had no direct connection with their profession. Anybody else would have been killed under the same circumstances. And it is useless to blame the motorman, who paid with his life for his error of judgment. Probably his passengers, having surrendered themselves, as passengers do, to the responsible care of their conductor, were paying no attention to the signs of danger which it was his business to heed. Without expressing condemnation of any one, I think it fair to interpret this catastrophe as an illustration of the strange, abnormal and half-hysterical recklessness which has come in with the introduction and wonderfully sudden extension of the use of automobiles. There is a subtle influence in mere speed of motion, which impels to the taking of risks. Many owners of automobiles have told me of the difficulty of keeping their drivers within legal or prudent limits. It seems to me that engineers, who know the danger more accurately than others, should be, for that reason, more vigilant and stern in prohibiting every unnecessary encounter with it. One cannot preach to the dead; but I hope this warning may reach and influence the living.

The premature death of Mr. Coleman deprived his professional colleagues and the industrial world of a man possessing the qualities most needed in this generation—intelligence, independence, integrity, and industry, coupled with cheerful courage and courtesy.—R. W. R.

Paul A. Fusz was born Aug. 5, 1847, at Hericourt, France. In 1858, he came with his parents to St. Louis, Mo., where, after receiving a public-school education, he entered, as errand-boy, the employ of the firm of Chouteau, Harrison & Valle. Through

successive promotions, he reached in 1873 the position of General Manager, having entire charge of the Laclede rolling-mills, located in North St. Louis, and the deliveries of iron-ore from the Iron Mountain mine, owned by the company. In June, 1886, he became Treasurer, and in October, 1888, Superintendent of the Granite Mountain Mining Co. of Montana. In October, 1889, he was elected President and Manager of the Bimetallic Mining Co.; and when in 1896 these two enterprises were merged as the Granite-Bimetallic Consolidated Mining Co., he was made President of the new corporation, a position which he continued to hold until death. He was also, as late as 1908, President and Manager of the Hope mine—said to be the oldest silver-mine in Montana—President and Manager of the American Gem Mining Syndicate, operating mines in Montana, North Carolina, and Canada; Director of the Desloge Mining Co. of Missouri, and other mining and industrial corporations. He became a member of the Institute in 1879. His death, after a very brief illness, occurred in St. Louis, Feb. 16, 1910.

John Wellington Nesmith was born Jan. 4, 1834, at Chillicothe, Ohio. His Scotch ancestors came to America in 1719, and several of them were officers in the Continental army. In 1860, at the age of 26, Mr. Nesmith joined the company of the pioneers who laid the foundation of the splendid history of Colorado. Engaging first in the business of mining and milling in Gilpin county, he was quick to realize the demands of that industry for the manufacture of castings and machinery suited to local conditions and deliverable promptly to local operators. At an early day he became connected with Langford & Co.'s foundry, the nucleus of the famous Colorado Iron Works, of Denver, of which he was made Manager in 1879 and President in 1886. Under his direction, these works constructed mills and smelters for gold, silver, lead, and copper. It is reported that their customers were found not only throughout the United States, Canada, and Mexico, but also in Central and South America, England, Holland, New Zealand, Tasmania, South Africa, and Japan. Such a geographical distribution of products is in itself a proof, not merely of their excellence, but also of their special fitness for particular uses; and this was the

result of Mr. Nesmith's practical skill as an engineer and mechanic, coupled with his keen perception of needed improvements and his courage in adopting them. His enterprise was not confined to this field alone. He was associated with Governor Evans in the construction and operation of the South Park railroad. From 1884 to the end of his life, he was a member of the Denver Chamber of Commerce, a Director in 1886 and Vice-President in 1887. He served as State Senator from Gilpin county, held high rank as a Royal Arch Mason, and was a member of the Colorado Scientific Society and other institutions. Down to three or four days before his death, he was apparently in vigorous health, and actively attending to business affairs. After he was 60 years old, he took up and mastered the Spanish language; and during recent years he had been pursuing with the zeal of youth the use of petroleum as a metallurgical fuel, and perfecting for that purpose a system and apparatus which others must now test in practice.

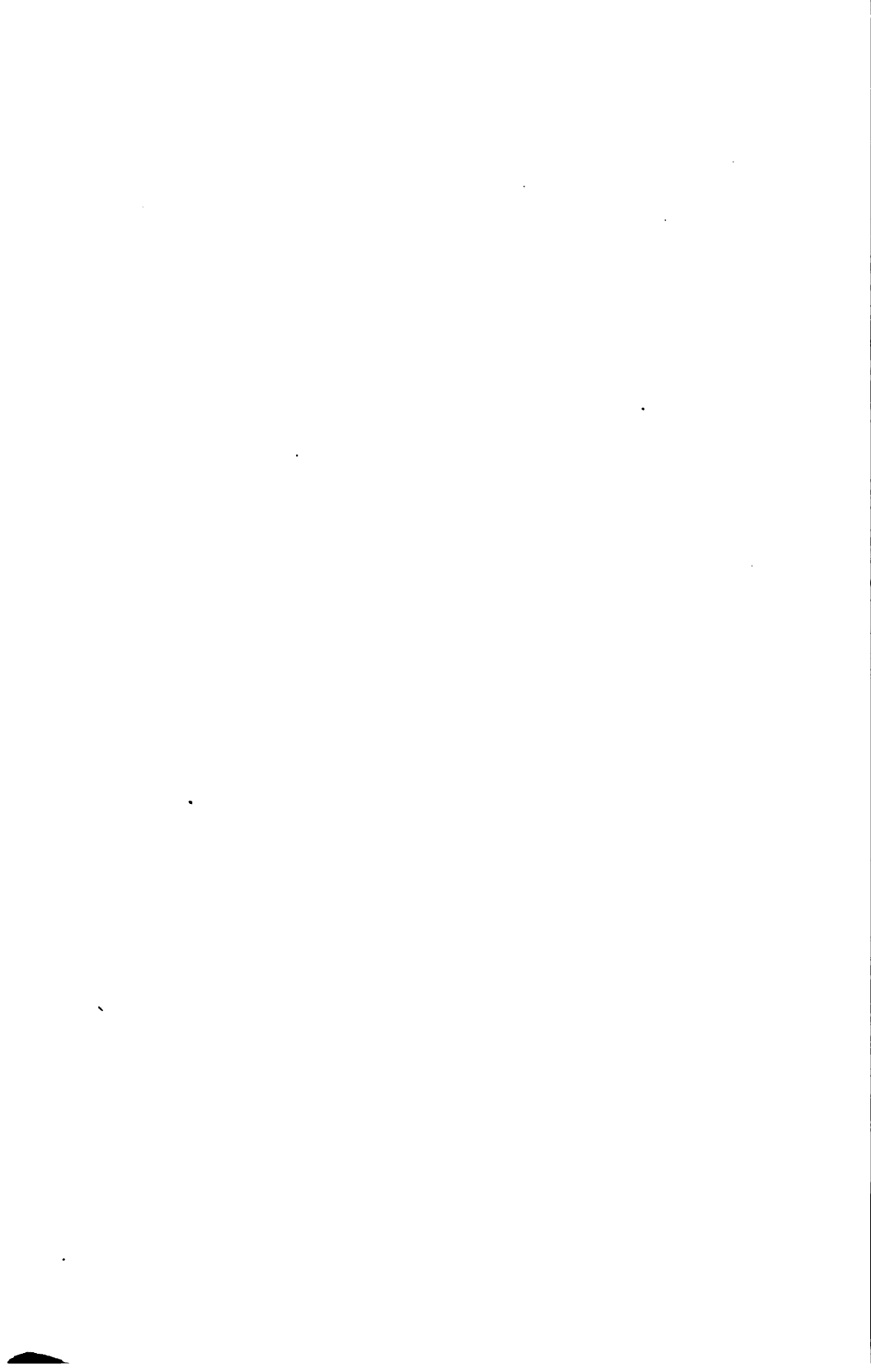
Mr. Nesmith joined the Institute in 1896. Those who took part in the Spokane meeting and excursions last year, remember with pleasure his genial presence and the enthusiasm with which he entered into all the experiences of the journey.

His death, Dec. 17, 1909, after an operation for gall-stones, came as a great shock and sorrow to a host of business and personal friends; and the community in which he so long resided and labored laments the sudden termination of a long, useful, influential, and stainless life.—R. W. R.

Ferdinand Herman Regel was born Oct. 7, 1876, at St. Louis, Mo., and immediately upon graduation at the Smith Academy in that city, entered the Missouri School of Mines at Rolla, where he remained two years. This course of study he followed with two years at the Royal Saxon Mining Academy of Freiberg. Returning to this country in 1899, he became assayer and surveyor for the American Gold Mining Co., Ouray, Colo. In 1900, he was employed as assistant engineer by the Sombrerete Mining Co., in Zacatecas, Mex., and, a few months later, became the head of its engineering department. It was at this time that he was elected a member of the Institute. A little later, he returned to St. Louis, where he connected himself with the Arthur Fitch Foundry & Machine Co., and also opened

an office as consulting mining engineer and metallurgist. He died Jan. 18, 1910.

Mr. Regel contributed to the *Transactions* a valuable paper on The Klein Jig and the Klein Classifier (*Trans.*, xxxi., 619).



Mining-Conditions in the Belgian Congo (Congo Free State).*

BY SYDNEY H. BALL, NEW YORK, N. Y., AND MILLARD K. SHALER,
LAWRENCE, KAN.

(Pittsburg Meeting, March, 1910.)

I. INTRODUCTION.

DURING the past 50 years the attention of mining-men has been turned to Africa, and within the past decade prospecting-expeditions sent into Central Africa have resulted in the opening-up of several mines. Having recently spent two years in the Belgian Congo for the Société Internationale Forestière et Minière du Congo, it is our purpose to outline briefly the mining-conditions in that part of Central Africa. Before it became, in 1908, a Belgian colony, this region was known as the Congo Free State.

II. LOCATION AND AREA.

The Belgian Congo lies in southwestern Central Africa, west of the continental divide, as illustrated in Fig. 1. It has a coastline of but 20 miles on the Atlantic, but widens rapidly eastward to points 5° north and 14° south of the equator. Its area is 908,000 sq. miles, which is almost one-quarter that of the United States and Alaska, or more than one and one-half times that of Alaska. Stated in other terms, its area is nearly one-third that of the United States, exclusive of Alaska and the insular possessions, or more than that of all the United States east of the Mississippi river.

III. TOPOGRAPHY AND DRAINAGE.

From north to south, Africa is made up of three topographic elements: 1, the Atlas mountains, a highly-accentuated region

* Presented by permission of the Société Internationale Forestière et Minière du Congo.

of closely-folded rocks; 2, the Soudan and Sahara desert-regions, a more or less accidented plain in which the rocks are in the main flat-lying; and 3, the central and southern table-lands with the Abyssinian plateau, consisting of intensely-folded older and horizontal younger rocks.

The Belgian Congo, with the exception of the coastal

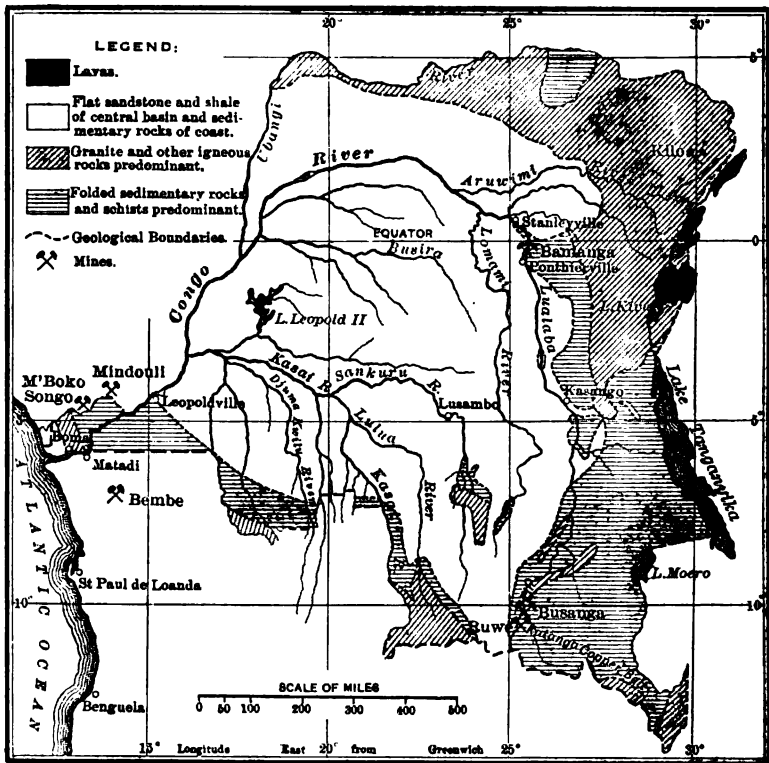


FIG. 1.—MAP SHOWING MINING-LOCALITIES AND APPROXIMATE GEOLOGICAL BOUNDARIES IN THE BELGIAN CONGO.

plain, lies within the plateau region and consists, from west to east, of:

1. A narrow coastal plain, which faces the Atlantic ocean, rising to

2. An ancient mountain range, now eroded to an intensely-dissected plateau, and frequently referred to as the Crystal mountains. The higher domes reach an altitude of 2,800 ft. Through the hard rocks of this plateau the mighty Congo

rushes in a series of rapids and low water-falls, the non-navigable stretch between the lower and the upper Congo rivers.

3. The great interior region, a basin whose slopes rise gently from Lake Leopold II. (altitude, 1,110 ft.). The limits of the basin to the north (altitudes from 2,500 to 4,200 ft.) and to the south (from 4,000 to 5,200 ft.) are comparatively low, but to the east rise to

4. The Eastern Frontier mountains, in height averaging about 1 mile above sea-level. Certain peaks, like the volcanic Ruwenzori (altitude, 16,800 ft.), are much higher. These mountains are in part due to folding, but largely to N-S. faulting, with which are genetically connected important volcanic phenomena.

The Congo river and its tributaries drain all of the Belgian Congo with the exception of a small area in the extreme northeast, the waters of which find their way into the Nile. With the exception of Brazil, no tropical country is blessed with such a system of water-ways as is offered by the Congo and its principal affluents, the Kasai, Sankuru, and Ubangi. Bertrand,¹ giving its length as 4,640 km., says that the Congo is the sixth longest river in the world.

Contrary to the opinion generally held regarding tropical countries, one-half of the Belgian Congo is savanna; the other half, forest. Practically all of the great equatorial forest lies between the fourth parallel south and the fourth parallel north of the equator, and is, for the most part, confined within the great horseshoe of the Congo river. Elsewhere small groves or even forests are not unusual, yet the country is typically savanna, with sparse and generally scrubby trees here and there. As the equatorial forest is approached, the streams are generally bordered by a narrow fringe of dense forest.

The Belgian Congo has a typically tropical climate, with heavy rain-fall, high humidity, and relatively high, though diurnally variable, temperature. Heavy rain-fall, or its absence, characterizes the two seasons, excepting very near the equator, where it rains more or less regularly every month in the year, and where seasons do not exist. North of the second parallel north, however, the seasons are well marked; the dry season, which

¹ *Le Congo Belge*, p. 46 (1909.)

is considerably cooler, begins late in October and ends early in May, followed by the rainy season, which lasts six months. The seasons are, naturally, reversed south of the equator.

IV. GEOLOGY.

The geological boundaries are shown approximately on the map, Fig. 1, which gives also the mining-localities.

The coastal plain is underlain by marine sandstones, which are inclined gently towards the ocean. The sandstones, which are covered by recent alluvium at the Congo mouth, are, according to Zboinski,² of Tertiary and Cretaceous age.

The so-called Crystal mountains consist of older rocks, the age of which has not yet been satisfactorily determined. The strike of these rocks is NNW., and the predominant dip is east. The older rocks of the series occupy the west part of the belt, and the degree of metamorphism increases progressively from east to west. What are apparently the oldest members consist of mica-schists and sericitic quartzites, interbedded with which are chlorite- and epidote-schists, representing either basic lavas, contemporaneous with the sedimentary rocks, or very ancient intrusive bodies of igneous rocks. Of later origin are intrusive masses of granite and gabbro, now mashed and recrystallized into gneisses. Large bodies of massive granite and smaller ones of diabase also occur. To the west of these older rocks are limestones and calcareous schists, which near the ancient complex are closely folded, but are flat-lying further east, half-way between Matadi and Leopoldville. These beds are considered by E. Dupont³ to be of Devonian age. To the east they are unconformably overlain by red sandstones and shales, the Kundulungu (Permo-Carboniferous) of Prof. Jules Cornet.⁴ African geologists and engineers owe a debt of gratitude to this Belgian *savant*, as the most important contributor to Belgian Congo geologic literature, both scientific and economic.

The great interior region is covered by interbedded sandstones and shales, either flat-lying or dipping gently towards the center of the basin. The lower surface of this formation is

² *Bulletin de la Société Belge de Géologie, de Paléontologie et de Hydrologie*, vol. i., pp. 36 to 41, Mémoires (1887).

³ *Ibid.*, vol. ii., pp. 47 (1888).

⁴ *Ibid.*, vol. xxi., pp. 365 to 382 (1907).

undulating, and it apparently thins rapidly on the upper slopes of the basin. As the rim of the basin is approached, isolated inliers of older folded and faulted rocks begin to appear in valleys cut through the sandstone-shale blanket. Upon the rim itself these older rocks greatly predominate and are similar, in a general way, to those of the Crystal mountains.

These older rocks consist of very ancient mica-schists, quartzites, and igneous schists and gneisses, which are cut by gabbros and granites. Younger than the granites are folded sandstones, quartzites, slates, shales, and limestones. Cornet, in believing that these two series of rocks are respectively of pre-Cambrian and Palæozoic age, is without much question correct, although, unfortunately, fossils have never been found in them. In the eastern mountain-area there are also modern and Tertiary lavas, which up to date have not proved to be ore-bearing.

The main structural features on the north and south rims of the Congo basin have an E-W. trend, while the rocks of the eastern mountains strike N-S. The position of lakes Tanganyika, Kivu, Albert Edward, and Albert, and of the mountain ranges nearby, has been determined largely by faults, the trends of which are approximately parallel to the strike of the rocks.

V. PROSPECTING.

The flat-lying sandstones and shales of the central basin are apparently without important mineral deposits. In the older rocks, and in the gravels derived from them, bodies of ore occur, some of which are exploitable, even under the excessively high mining-costs of Central Africa. While over one-half of the Belgian Congo is thus valueless, from a mining standpoint, the rest of the country is so rich that no serious prospecting-expedition of capable men has ever returned from there empty-handed.

While trading-posts were established at the mouth of the Congo river in the early part of the nineteenth century, the opening up of the hinterland dates from Stanley's marvelous descent of the Congo in 1877, from where Nyangwe now stands. Following his discoveries, the International African Association and the International Association of the Congo were successively launched, to be replaced later by the Congo Free

State, with Leopold II., of Belgium, sovereign ruler. In November, 1908, the Belgian government took over this State as a colony. During the past 25 years no tropical country has been more rapidly explored, nor more highly developed commercially, and for the past decade prospecting has been most active.

The Belgian Congo is divided into concessions, Fig. 2, which are in the hands of more or less powerful groups of capitalists. Within these concessions, these companies have the exclusive prospecting-rights and the rights to the mines found, under conditions varying according to the articles of their charters. Throwing the region open to free, unrestricted prospecting by individuals would unquestionably cause great suffering and loss of life, since the members of improperly-equipped expeditions would undoubtedly perish, and the necessary protection could not be given by the government to all comers. To get into this country equipment, European food-stuffs, and the medicines and luxuries necessary to the white man, is an expensive undertaking.

At present, most active prospecting is being carried on by the Société Internationale Forestière et Minière du Congo, the Chemin de fer des Grands Lacs, the Comité Spécial de Haut-Katanga, and by the government itself.

VI. MINING.

Up to date the product of the Belgian Congo mines has been small. Shipments of from 70 to 80 kg. of gold per month are reported from the Kilo gold-mines, and considerable gold—10,900 oz. up to Sept. 30, 1905—has been produced from the Ruwe (Katanga) mine. Shipments, up to the present time, from the Katanga copper- and tin-deposits and from the Bamanga copper-mine, near Ponthierville, have been small and almost entirely for the purpose of milling and metallurgical testing. The copper-ore exported in 1908 was valued at \$24,700. The double question of labor and transport is at present the serious obstacle to exploitation.

1. *Gold.*

This precious metal is widely distributed among the older rocks of the Belgian Congo, and is even present in small quan-

tity in certain areas within the central sandstone-shale area. Stanley states that the Arabs, at the time of his entrance into the country, washed some gold from the streams in the eastern part of the Congo basin, and Cameron writes that Zanzibarites got gold from some of the Katanga streams. Certain deposits which have been found within the past two years have not been opened up, but the following mines are being operated:

a. *Kilo Gold-Mine*.—This mine, Fig. 3, situated among the head-waters of the Ituri river, just west of Lake Albert, is a State property and reliable information regarding it is difficult to obtain. The predominant country-rock is granite, and free gold has been found in quartz veins in the vicinity. The deposit, which was discovered six years ago and is now being exploited by the State, is a rich placer covering a wide area. About 25 whites, including ten prospectors, and several thousand blacks are employed. Prospecting is being constantly done in the vicinity. The monthly output, with rude sluices and very little machinery, is rumored to be from 70 to 80 kg. It is reported that a hydraulic plant is to be installed shortly.

b. *Ruwe Gold-Mine*.—Ruwe is situated near the Rhodesian frontier, in southeastern Belgian Congo, near the source of the Lualaba. Up to Sept. 30, 1905, the production, all obtained by sluicing the detrital deposit, was 10,900 oz. of gold. The *Tribune Congolaise* of Sept. 16, 1909, reports that the mine will shortly shut down, pending the arrival of the Cape-to-Cairo railway, as machinery is now needed.

The country-rocks are sandstones and quartzites, which dip from 12° to 35° N-E., and are cut, as is the ore-body, by faults trending NW-SE. The ore-body as developed consists of an indurated, banded sandstone, and is 1,200 ft. long, with an average width of 8 ft., but varying from 3 to 20 ft. The walls are sandstone, though at the surface, uphill from the deposit, is a band of limonite-cemented conglomerate. The values, which are patchy, average \$17 per ton, and consist of gold, platinum, silver, and palladium. More or less iron, cobalt, nickel, lead, and copper are associated, the last two occurring as the vanadates, psittacinite and vanadinite and cuprodeschoizite, while pyromorphite and malachite also occur. These minerals form the "green concentrates," which are a good value-indicator. The metals platinum, palladium, and silver increase

and decrease in volume together, but gold is independent of the others. Values are rarely visible in the ore.

Immediately downhill from the outcropping ore-body, the detrital material contains nuggets, some of which are 2 in. in diameter, of gold alloyed with more or less silver. Platinum is practically lacking in this soil.

Of the two men who have described Ruwe, Studt believes that the ore was deposited by magmatic hot waters derived from what he considers an igneous dike, now represented by ferruginous clays. Buttgenbach,⁵ on the contrary, believes the ore-bodies to be old beach-placers which were interbedded with the finer sediments when the sandstone series was deposited. Both agree that the gold of the detrital deposits was dissolved from the ore-body and re-deposited in the detrital material. This belief in the surface formation of the larger nuggets is based, first, on the absence, in the ore-body, of nuggets; second, on the lack of platinum in the detrital material and its presence in the ore-body; and third, on the form of some of the nuggets, which resembles, in instances, that of organic remains.

c. *Other Deposits in the Katanga.*—The ore of many of the Katanga copper-deposits carries a small gold- and a somewhat larger silver-content, but in rare instances only is it worth separating. Derived from the Katanga and Fungurume copper-deposits are, however, important gold-placers.

2. Copper.

Copper occurs widely in the older rocks of the Belgian Congo, and the Katanga Copper Range is a most important high-grade copper reserve. Of less importance are the deposits of Bamanga, near Ponthierville, and the Bembe and Mindouli copper-deposits in Angola and the French Congo, respectively.

a. *The Katanga Copper-Deposits.*—Mining and smelting of

⁵ *Annales du Musée du Congo*, Second Series, vol. i., p. 57 to 69 (1908). *Annales de Société Géologique de Belgique*, vol. xxxiii., Mémoires, p. 65 to 67 (1905-06). *Revue Universelle des Mines, de la Métallurgie, des Travaux Publics*, etc., Fourth Series, vol. xiv., pp. 114 to 147 (1906). Farrell, J. R., Studt, etc., *Tanganyika Concessions, Ltd.*, various reports (1900 to 1906).

copper-ores has been followed for centuries by the natives living near the Katanga copper-mines, and the majority of the mines of the Tanganyika Concessions, Ltd., are black men's mines which have been relocated by whites. Some idea of the extent of their operations is indicated by the report that at Linishia one pit is 720 ft. long, 30 ft. deep, and 480 ft. wide at one end, tapering to a point at the other. The importance of the dependent commerce in crude copper (cast into St. Andrew's crosses, worth in trade goods about \$8) is shown by the fact that they reached points 400 miles away from the mines. From the crude copper, bracelets and other articles of adornment and ornamentation, and even copper wire, were made by the village coppersmiths.

At present the copper industry is unimportant among the Katanga natives. Their system of mining and smelting is as follows: Large pits are sunk in the softer parts of the ore-bodies to depths approaching 40 ft. The crumbly ore and gangue is placed in baskets and is then carried to a nearby stream, where the basket is submerged rim-deep and washed, much as one washes gravel in a gold-pan. Soon malachite alone remains, which is emptied into a pile, and the miner returns for more ore. The won malachite at nightfall is carried to the village, where it is smelted much as the iron-ore is smelted, in furnaces made usually from ant-hills. Forced draft is furnished by roughly-constructed hand-bellows.

The Katanga copper-deposits⁶ are situated in southeastern Belgian Congo, about 11° S. of the equator, and not far north of the Rhodesian frontier. Up to date about 100 deposits are known, included within a belt extending 90 miles east from the Lufupa river, thence bending suddenly SE., and reaching a point 110 miles away.

Livingston, Burton, Cameron, Joseph Thomson, and Wissman all state that the natives reported rich copper-mines to

⁶ Cornet, Jules, *Bulletin de la Société Belge de Géologie*, etc., vol. xvii., pp. 3 to 47, Traductions et Reproductions (1903.) Buttgenbach, H., *Annales de la Société Géologique de Belgique*, vol. xxxi., Mémoires, pp. 515 to 572 (1903-04). Buttgenbach (practically the same article), *Annales de Musée du Congo*, Second Series, Katanga, pp. 1 to 51 (1908). Farrell, J. R., and Gray, G., etc., various reports, Tanganyika Concessions, Ltd. (1900 to 1906). Farrell, J. R., *Engineering and Mining Journal*, vol. lxxv., No. 15, pp. 747 to 753 (Apr. 11, 1908).

exist in the Katanga. Reichard¹ in 1883 was, however, the first white man to see these deposits, and he was soon followed by Capello and Ivens, Portuguese travelers, and later by the Scotch missionary, Arnot. It was, however, Professor Cornet who, in 1892, first brought back satisfactory data concerning these deposits.

In 1900 the representatives of the Congo Free State government intrusted the investigation of this mineral region to the Tanganyika Concessions, Ltd., of London. Through the able efforts of the officers of this company, particularly Messrs. Williams, George Gray, and J. R. Farrell, the American engineer, and F. E. Studt and the Belgian representative, Monsieur H. Buttgenbach, the value of the Katanga copper-region has been proved.

These deposits are situated in a plateau whose surface has been dissected into a region of rounded hills and rather steep-sided valleys. Elevations of the higher hills and the lower valleys are respectively 5,300 and 4,000 ft. above sea-level. The copper-bearing strata are harder, as a rule, than the rocks of the surrounding country, and, in consequence, the ore-deposits are usually located on hills. These hills, in contradistinction to the surrounding timbered country, are bare of trees and shrubs, and between them and the forests grow the misuka or mahobohobo bush, which is here a most excellent copper-indicator. This de-forestation, due, unquestionably, to the presence of the deadly copper-salts in solution in the soil and sub-soil, has proven a valuable aid in prospecting.

The copper-deposits are situated in quartzose strata varying from incoherent sandstones to quartzites, and in schists, slates, and limestones. According to Buttgenbach, eruptive rocks are not closely connected with the deposits. The sedimentary rocks strike generally WNW., and dip, as a rule, steeply. Sharp folding, faulting, and brecciation are common in the vicinity of the ore-deposits.

The more abundant copper-minerals of the Katanga ores, which average about 15 per cent. of copper, are malachite, chrysocolla, azurite, and melaconite, while cuprite, diopside, native copper, and chalcopyrite are rare. Finely-divided chry-

¹ Reisenach, Urua-Katanga, *Mittheil der African Gesellschaft in Deutschland*, vol. iv., No. 5, p. 303 (1885).

socolla, azurite, and malachite are found impregnating the country-rocks, and also in the form of botryoidal and mammillary masses, the three minerals being frequently closely associated with one another. Calcite layers occur in such masses, and malachite in some cavities takes the form of stalactites. Melanconite, while often associated with these carbonates and silicates, occurs also in ore intimately mixed with limonite and manganese dioxide. Beds of hematite are not rare in the vicinity of the copper-deposits, and this mineral is one of the most important gangue minerals. Besides those already mentioned, quartz is a common gangue mineral, and barytes has been found at Kambove Mine No. 1. Analyses show the ore to be a siliceous one, notable for the presence of nickel and, in instances, traces of gold and silver.

The ore-bodies vary in size from comparatively small to mammoth ones, such as Kambove No. 2, reported to be 3,000 ft. long and, so far as tested, from 240 to 400 ft. wide. It is said to contain 10,000,000 tons of 15-per cent. copper-ore in each 100 ft. of sinking. These ore-bodies are remarkably alike in mineral paragenesis and in form, and probably all have a common origin. The deposits consist of lens-like masses, with their longer dimension parallel to the strike of the rocks, and in the greater number of cases the ore-body follows the dip. The ore is usually contained within rather well-defined walls. Near the center of many of the deposits, and parallel to their extension, is a sugary, sandy quartz, much fissured, in which copper carbonates and oxides occur in large masses. Away from this quartz band the country-rock is impregnated with malachite, chrysocolla, and azurite. In schists, thin sheets of these minerals occupy the closely-spaced schistosity-planes in such a way as to remind one, looking across the schistosity, of a book whose leaves are alternately green and white. Where the rocks are fractured or brecciated, veins and nodules of the carbonates and oxides occur. Chalcopyrite has been found in small veins, and at the Musonai mine impregnates the sandstones. This sulphide is more or less altered to malachite, chrysocolla, and limonite.

Cornet believes these deposits to be the "iron hats" of copper sulphide bodies, as does Buttgenbach, who expects, further, that the sulphide body will consist of chalcopyrite, bornite,

hematite, and magnetite, in a vein or veins parallel to the bedding of the sedimentary rocks. The frequent presence of the medial line of quartz suggests that the original deposits were fissure-veins, with the country-rock nearby more or less impregnated with chalcopyrite. Since the Katanga has suffered notable erosion, the oxidized ore-bodies, as exposed, doubtless contain the equivalent copper-content of many feet of narrower veins which have been removed by erosion. As a result, the sulphide veins, when found, may be considerably narrower than the outcropping oxidized ores.

Lying, as it does, 10° S. of the equator and more than three-quarters of a mile above sea-level, the Katanga enjoys a climate rather favorable to white settlement. The native labor-supply is fair, timber is sufficiently plentiful for mining needs, and, while coal is lacking, electric power-plants can be readily located near the mines. The ore, being soft, is easily mined, and the deposits, being on hill-tops, can be quarried or worked by steam-shovels for a considerable time. The necessary hematite and limestone for smelting purposes are at hand, and the company engineers report that sufficient oxidized ore has been opened up to meet all demands for many years.

The actual production of copper or copper-ore merely awaits the arrival of the Cape-to-Cairo railroad, which has recently reached the Rhodesian frontier from the south, and presumably many of the deposits will be producing mines within less than two years.

b. The Bamanga Copper-Deposit.—This deposit, which was casually examined by one of us in 1908, lies on a small island in the Congo river, about 7 miles below Ponthierville. It was then and is now, according to report, being actively developed by a sub-company of the Chemin de fer des Grand Lacs.

The country-rocks seen consist of a red arkositic sandstone or quartzite, which is presumably younger than a coarsely-porphyrific biotite-granite gneiss with which it is in contact. With the granite-gneiss is a little hornblende-biotite gneiss, evidently representing a mashed basic igneous rock. These rocks dip steeply, the strike being roughly E-W. The ore occurs in parallel veins, cutting all the country-rocks, or what is equally probable, in short lenticular bodies, in fractures more or less continuous, and, in part at least, faults. These ore-bodies, as

exposed in the open-cuts, vary in width from 0.5 in. to 2 ft., and strike a little east of north.

The original minerals, filling the fracture-cavities and incasing the included fragments of country-rock, are quartz, chalcocite, and chalcopyrite. The first two are frequently well crys-

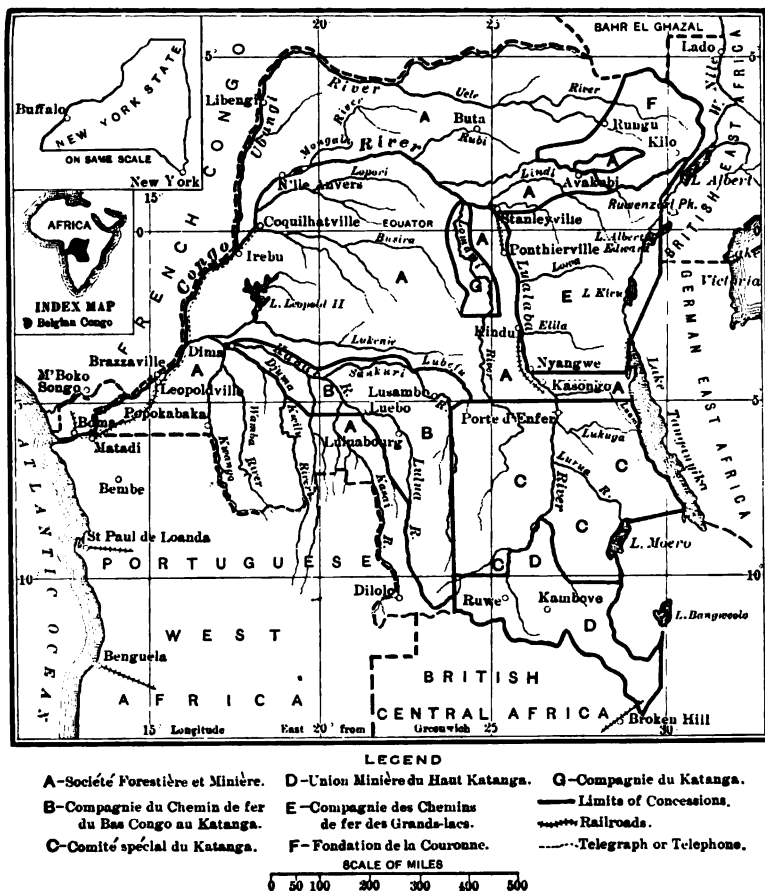


FIG. 2.—MAP OF THE BELGIAN CONGO, SHOWING RAILROADS AND MINING CONCESSIONS.

tallized in vugs. The secondary minerals are azurite and malachite, with some native copper and bornite. Picked ore runs from 31 to 55 per cent. of copper, and appreciable quantities of gold and silver are reported to be associated with it. In November, 1908, the monthly product was said to be 3 or 4 tons, with an encouraging monthly increase. In the general



FIG. 3.—GOLD-MINING AT KILO.



FIG. 8.—CANOE TRANSPORT, UPPER CONGO RIVER.



FIG. 4.—GNEISS BOULDERS COVERED BY RECENTLY-FORMED LIMONITE CONGLOMERATE, KASAI RIVER BANKS BELOW BANTUA SANKI. SUCH CONGLOMERATE IS THE CHIEF SOURCE OF THE IRON-ORE SMELTED BY THE NATIVES.



FIG. 7.—RAILROAD CONSTRUCTION, GRAND LAKES RAILROAD.



FIG. 9.—VINE BRIDGE ACROSS LUBEFU RIVER, LUBEFU.



FIG. 10.—EASTERN PART OF ROGGE CHUTE, UPPER KASAI RIVER, MAI MUNENE GNEISS OUTCROP.

vicinity, gold and silver occur in iron-stained fractures. In addition to small gold-placers near Bamanga, copper-placers are reported to occur along the river-bank, which was flooded at the time the mine was visited. Pebbles of rich copper-ore occur in these placers, in thin beds, inter-stratified with recent alluvial sands.

c. *The Bembe Deposit*.—Bembe⁸ is situated in Portuguese West Africa (Angola), about 110 miles inland from the Atlantic coast and 75 miles south of the Belgian Congo frontier. The deposits, long worked by the natives, were the property of several neighboring villages, but natives from other villages were permitted to work them on a royalty. Untimbered holes, 3 or 4 ft. in diameter, were sunk to from 24 to 30 ft. depths, with native hoes and trade knives. Descent into and ascent out of these holes was by means of wooden pegs driven into the sides of the pits.

The country-rock consists of clay-slates, and limestones, striking NW. and dipping steeply SW. The ore, largely malachite with some atacamite, occurs as masses imbedded in clays, apparently derived from the clay-slates. The lumps of ore, which has associated with it much iron oxide, vary in size from that of shot to masses weighing 3 tons.

d. *M'Boka Songo, Mindouli, and Abikula Deposits*.⁹—In the French Congo, just north of the Belgian Congo frontier, is a belt of copper-deposits, more or less continuous, stretching in an ENE. direction through a distance of 60 miles. M'Boka Songo and Mindouli, the better known of these deposits, occur respectively at the western and eastern limits of this belt. These two deposits have been mined by the natives for centuries, and even at the present day, in the dry season, from 800 to 850 natives are said to work at Mindouli. One pit for copper, made by natives at M'Boka Songo, is said to be 400 m.

⁸ Monteiro's *Angola and the River Congo*, vol. i., pp. 189 to 196 (1875). Thomas, Lewis, *The Geographical Journal*, London, p. 604 (1908).

⁹ De Launay, *Les Richesses Minérales de l'Afrique*, p. 124 (1904). M. Barrat, *Annales des Mines*, Ninth Series, vol. vii., pp. 460 to 468 (1895). M. Levat, *Annales des Mines*, Tenth Series, vol. xi., pp. 1 to 65 (1907). M. Bertrand, *Revue Générale des Sciences*, pp. 792 to 796 (1895). A. Le Chatelier, *Comptes Rendus des Séances de l'Académie des Sciences*, vol. cxvi., No. 17, pp. 894 to 896 (1893). Dupont, *Lettres sur le Congo* (1889). Brien, V., review of forthcoming publication on copper-mines in French Congo, *Tribune Congolaise* (Sept. 23, 1909).

long by 60 m. wide and 20 m. deep. Both copper- and lead-ores are smelted in small crucibles there. While malachite is the ore much preferred, chalcocite is recognized by the blacks to contain a high percentage of copper, and they add a bit of it to the charge. Shipments of malachite were formerly made to Marseilles, but heavy transport-charges rendered this unprofitable. At present, however, a narrow-gauge railway is being constructed between Brazzaville, on Stanley Pool, and Mindoula, and active exploitation will soon begin.

There are two chief country-rocks in this hilly region: a limestone with a thin conformable sandstone layer above it, generally referred to as Devonian; and an unconformable reddish sandstone, accompanied by argillaceous mica-shales, fissile, and brick-red in color, supposed to be the equivalent of the Karoo sandstone of South Africa. Pebbles of the former country-rock have been found in the latter.

At M'Boka Songo the ores chiefly occur imbedded in clay pockets in the irregularly-weathered surface of the limestone. There are also more or less tabular deposits near the contact of the limestone and the conformably overlying sandstone. At Mindoula the tabular deposits at or near the contact predominate, and these ore-bodies coincide in dip, as a rule, with the country-rocks. The limestone, in the vicinity of the ore-bodies, is silicified, and in instances is a veritable stockwork of veinlets of chalcocite. Sheets of ore follow down the joints in the limestone.

The ores present are numerous and many of them unusual. They include malachite, azurite, diopside, chalcocite, tetrahedrite, and black copper oxide, argentiferous galena, cerussite, and wulfenite, calamine and willemite, limonite and an iron phosphate, and native silver. As gangue minerals, calcite, quartz, and a carbonate of manganese are present.

At M'Boka Songo the country-rock is highly calcareous, while at Mindouli and Abikula it is more siliceous. As a consequence, through mass chemical action, silicates predominate at Mindouli and Abikula and carbonates are the main ores at M'Boka Songo.

As is true of many mineral deposits where the workings extend to no great depth, the origin of these ore-bodies is a mooted question. Barrat and most of the older investigators

believed them to be the oxidized portion of veins, the secondary minerals replacing the limestone to some extent. He believed the deposits to be genetically related to the intrusion of a diabase which cuts the limestone in this general vicinity. Levat believes, as does apparently Brien, that the minerals were originally deposited in the overlying conformable sandstones, and that, through leaching, concentration, and re-deposition, they are now found in the limestone, the composition of which is favorable to replacement.

3. Tin.

While cassiterite has been found at several and reported from many localities in the Belgian Congo, it is only in the Katanga¹⁰ that deposits rich enough to exploit in the future have been found. The tin-belt of the Katanga is situated on the west slope of the rugged Bia mountains, and extends NE. from a short distance north of Ruwe to a point not far south of Lake Kabele through a distance of some 110 miles. The rock of these mountains is a biotite granite, which to the west intrudes mica schists, slates, and quartzites, carrying tourmaline. The sedimentary rocks are considered by Studt¹¹ to be of Silurian age.

The tin-deposits are of three kinds: 1, quartz-muscovite-cassiterite veins; 2, residual deposits from these; and 3, placers derived directly from the other two sorts of deposits. The veins for the most part are situated in the sedimentary rocks near the granite, but sometimes are in the granite itself. They are vertical and occur in two sets, one quite regular in values striking NW., the other at right angles, sometimes richer but less constant than it in content. The veins are from 300 to 4,000 ft. long. Cassiterite occurs in good and often very large crystals, imbedded in quartz, and is frequently more abundant near the borders of the veins. Undoubtedly these veins are dependent in origin on the after-effects of the granite intrusion.

The residual deposits, most important economically, are derived from the breakdown of these veins. The tin-bearing

¹⁰ Buttgenbach, *Annales de la Société Géologique de Belgique*, vol. xxxiii., Mémoires, pp. 49 to 52 (1905-06). Buttgenbach, *Carte Géologique du Katanga, Annales du Musée du Congo*, Second Series, Katanga, pp. 70 to 72 (1908). Various reports of the Tanganyika Concessions, Ltd. (1900 to 1906).

¹¹ Studt, *Annales du Musée du Congo*, Second Series, vol. i., p. 14 (1908).

layer averages 2 ft. in thickness, and carries a mean tenor of 1 per cent. of tin. These deposits, discovered in 1908, are estimated to contain 20,000 tons of tin of excellent quality. On the ground, early in 1906, some 8 tons of tin were smelted.

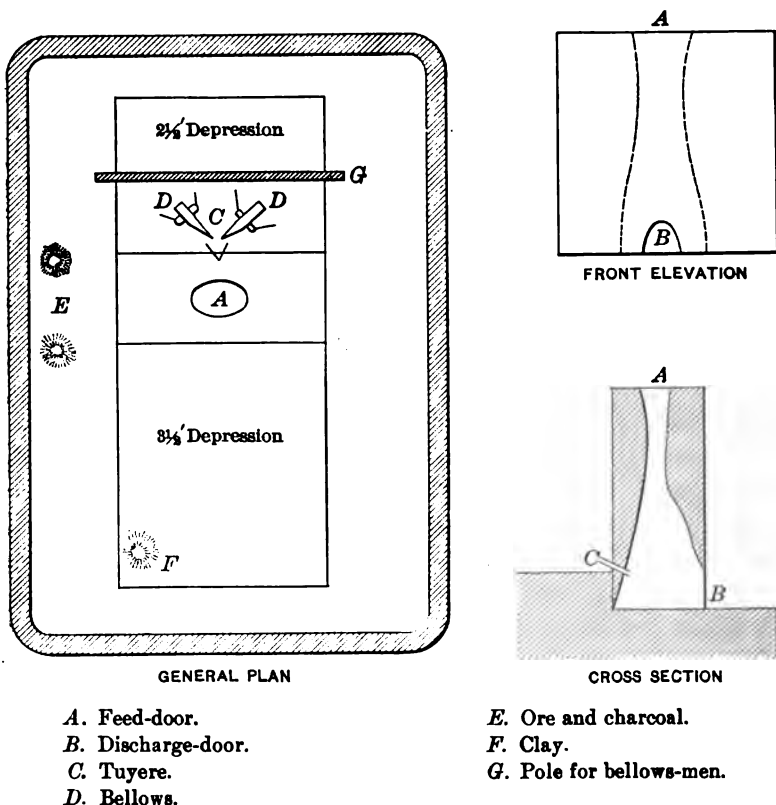


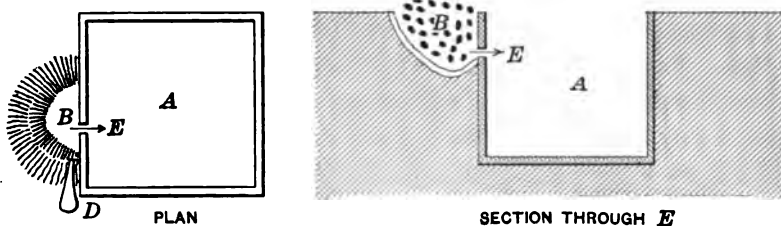
FIG. 5.—NONDO PRIMITIVE FURNACE.

The deposits are close to a navigable stretch of the Lualaba (Congo), and plenty of water-power is at hand.

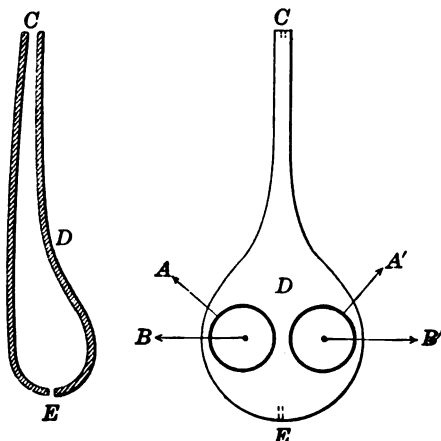
4. Iron.

Iron-ore of various grades is plentiful in the Belgian Congo, and indeed in that country is one of the world's more important iron-reserves. Since long before the white man's coming, Congo natives of many tribes have smelted iron-ore and skillfully fashioned the metal. The craft is highly rated among the natives, and not rarely descends from father to son, or at

least remains forever within a certain caste. The ore is derived largely from a recent iron-stone conglomerate, Fig. 4, which is widely distributed in the Belgian Congo. The limonite and hematite cement of this conglomerate is readily smelted by the natives, but is of too low grade and occurs in bodies too small for exploitation by the white man.



- A. 3- by 3- by 2.5-ft. clay-lined *buli*, or slag-collector.
 B. Shallow pit; open-hearth furnace in which are placed ore and charcoal; clay lined.
 C. Tuyere; clay cylinder.
 D. Bellows.
 E. Opening through which slag escapes.



Sketch of bellows. *A* and *A'*, loose leather caps, to be worked up and down by handles *B* and *B'*, compressing air in wooden shell *D*, which is expelled at orifice *C*. Valves at *C* and *E*.

FIG. 6.—DJUMA KWILU IRON-FURNACE.

In nearly every part of the Belgian Congo are primitive iron-smelters, and in principle they are very similar to either the shaft or open-hearth iron-smelters in civilized countries. The accompanying sketches, Figs. 5 and 6, show in a general way the characteristics of these furnaces, which are types used

respectively by the natives of the Djuma Kwilu region and of the mountains NE. of Kasongo.

The furnaces are in each case charged with small fragments of limonite and hematite, mixed with wood-charcoal, or in alternating layers with it. The blast is furnished by hand by means of a bellows constructed in general after the principle outlined in Fig. 6. The furnaces are usually clay-lined or are constructed directly in a huge ant-hill. The tuyere is of baked clay. The product is a more or less porous iron containing considerable slag and some charcoal. This iron is placed on a stone anvil, where it is freed from its impurities by pounding, and is then cleverly forged into knives, spears, bracelets, hoes, etc. Apparently the whole process depends for its success largely upon the benign oversight of the iron-maker's fetish, which is ever present when iron is to be made.

Among the Nondos, living to the east of the Lualaba (Congo) river and about 50 miles NE. of Kasongo, iron-smelting is highly developed. The natives actually mine with pointed sticks and iron spear-heads an impure hematite in shallow "gopher" holes and inclines. A part of the ore, a specular hematite, is obtained at Mauna Kusu, 30 miles away, and towards Kasongo. The chief smelters are located at Nyanga and Lumbukahula.

In the forests nearby, beneath rude thatches, logs, half-buried in the soil and partially sand-covered, mark the locations of charcoal "ovens." Long before reaching one of these villages the "puff-puff" of the bellows is heard, and upon arriving the well-built houses and comfortably-clothed natives speak of a prosperity unusual in Central Africa. In each village are several smelters, each inclosed in a clay house with banana-leaf-thatched roof. These buildings are 15 by 25 ft. in plan, with 8-ft. walls and a ridge 7 ft. higher.

The burnt-clay-lined furnace, as seen in Fig. 5, is roughly a blast-furnace of the shaft type on a small scale. The charge is, in part, made through the front opening, but largely through the top of the furnace. The front opening is closed during smelting by a large flat stone, clay-sealed, with the exception of two holes on either side for the escape of molten slag and iron. The charge, of 0.25-in. fragments of iron-ore and charcoal, is placed in alternate layers in the proportion, by bulk, of

one to four. Two runs are made per day, one from 5 to 11 a.m., the other between 1 and 7 p.m. Each run results in about 200 lb. of porous iron, which is hammered into a solid mass free from slag and charcoal. This in turn is forged by the smiths into hoes, knives, etc., which are much prized throughout the country.

Several natives tend the furnace, besides the two sweating, smoke-and-dirt begrimed bellows-men, whose job is not an easy one. All strenuously affirm that the Arabs had no influence upon the construction of their furnaces, but claim their knowledge of smelting and iron-working was a gift of the gods. It seems highly probable, then, that this trade was practiced among the Nondos before the Arab invasion. Before the white man's arrival, smelting was preceded by sacrifices of goats and chickens, to propitiate the gods and to assure a large yield. Whispers are also heard that even human sacrifices were not unusual.

In the Djuma Kwilu region, at and near Kivula, the natives use the type of furnace sketched in Fig. 6. Excepting in detail, the smelting- and working-processes are the same as with the Nondos. The latter work on a considerably larger scale, however, and near Kivula the type of furnace is distinctly "open-hearth."

There are, in the older rocks which rim the Congo basin, many deposits of hematite and magnetite of excellent grade, some of which are, in magnitude, to be compared only with the iron-deposits of the Lake Superior region. Our knowledge of these is at present, however, too meager to enumerate all of the classes of iron-ore deposits represented. Some are evidently magnetites of igneous origin (and related to gabbroic magmas); others metamorphosed sedimentary rocks, resembling the hematite-magnetite deposits of the Vermillion and Marquette ranges; again, others are replacements formed during the dying stages of granitic intrusions, and still others probably originated through the recrystallization and migration of material during regional metamorphism.

That huge iron-deposits exist in Central Africa is certain, and, in our opinion, before the end of the present century this region will become an important factor in the world's iron-production.

5. *Salt.*

In eastern Belgian Congo are a number of hot and cold saline springs, from which the natives have long obtained salt, an article highly prized among them. At Bena Sombo, near Nyangwe, rather strongly saline water, ranging in temperature between 44° and 47° C., bubbles gently from crevices in flat-lying shale at the wide head of a valley. The process of manufacture, which has been followed by the natives for generations, and has even made an important personage throughout the country of the chief, is as follows: Once a month, having insured an abundant flow of unusually saline water by the sacrifice of a goat to the fetish of the place, the villagers build around the springs low mud-and-rock embankments, thus impounding the water. From these ponds round earthenware pots are filled and carried to the village, where the salt weed, "medicine" to hasten evaporation, is thrown into them and they are placed over fires. The resultant salt is medium-grained and dark gray, due to the contained smoke and other impurities. Some 250 lb. is produced monthly, and, strange to say, this salt is generally preferred by the natives to the pure salt imported from Europe.

Years ago salt was obtained from four or five nearly-boiling and more or less intermittent hot springs, issuing at the extreme north end of Lubware peninsula in Lake Tanganyika. Due to some superstition, this work was abandoned, and it is now difficult to get the natives of the peninsula even to go near the springs. A liter of this water yields a heaping teaspoonful of fairly-pure salt.

Where such salt-springs do not occur, the natives in swampy places cultivate, or gather wild, certain grasses and water-plants which contain considerable potassium chloride. By burning these plants and permitting water to seep through the ashes, and then evaporating this water, potassium chloride is obtained, which serves as a substitute for salt.

6. *Silver and Other Metallic Products.*

Native silver, while present in association with the copper-ores of Mindouli, has not as yet been found in quantity in the Belgian Congo. The rarity of Tertiary and post-Tertiary igneous intrusions, with which silver-ores are so often associated in other countries, may explain this. With the exception of the occur-

rence of platinum and palladium in association with gold at Ruwe, these metals have not yet been definitely reported from the Belgian Congo. Lead- and zinc-ores occur sparingly with the copper-ores in the French Congo, and lead was there smelted by the natives.

7. *Non-Metallic Products.*

Up to date neither petroleum nor merchantable coal has been found in the Belgian Congo. Of the other non-metallic minerals, diamonds, salt, barite, allanite, copal, marble, and building-stones occur in more or less quantity. While diamonds have been found in the Katanga and elsewhere, there is no proof as yet that this precious stone occurs in workable quantity. Copal, in part fossil copal, and in part resin from present-day trees, is bought in small quantities from the natives by several commercial companies. In 1908 its export-value from the Belgian Congo was \$358,000. The other non-metallic minerals are not exploited.

VII. GENERAL MINING-CONDITIONS.

Transportation.

Matadi and Boma (from 18 to 20 days from Antwerp and Bordeaux) are at present the principal ports of entry for the Belgian Congo. Steamers leave for these ports from Antwerp every three weeks (Belgian Line) and once a month (Holland Line); from Bordeaux once a month; from Liverpool for the African West Coast every week; and from Lisbon to Cabinda, etc., every two weeks.

The northeastern corner of the colony is, however, served in part by the Nile steamers and railroad (Alexandria to Lado, 35 days), while the eastern frontier receives some supplies and mail by the Indian ocean ports, Dar-es-Salaam (German East Africa) and Mombasa (British East Africa). The trip by rail, steamer, and caravan, across British East Africa, requires from 30 to 35 days. Now that the Cape-to-Cairo railroad extends from Cape Town to the Belgian Congo frontier, it will naturally become more and more the outlet for the rich Katanga country. The railroad from Benguela bay (Portuguese West Africa), when completed into the Katanga country, may be a strong competitor of the Cape-to-Cairo road.

Within the Belgian Congo itself there are now three rail-

roads. The Mayumbe railroad extends 30 miles N. from Boma, and the lower Congo railroad connects Matadi, the seaport, with Leopoldville at the beginning of the Upper Congo navigation. This narrow-gauge road, which is 250 miles long, handles at present practically all of the exports and imports of the Belgian Congo. The Congo river is navigable from the terminus of this railroad (Leopoldville) to Stanleyville, a distance of 20 days by steamer, at which point the first division of the broad-gauge Grand Lakes railroad begins, Fig. 7, running to Ponthierville, about 80 miles up river. From the latter point there is a stretch of navigable river to Kindu, four days by steamer, where the second division of the railroad starts, which is now completed to a point opposite Kasongo. This division will be completed to Porte d'Enfer, above which the Congo is or can be made navigable to Lake Upemba, where a third division will begin, which, when finished, will complete the connection between the port of Matadi and the Katanga region.

Another railroad-line is being surveyed from Pania Mutambo—just above Lusambo—to the Katanga mining-region. In addition to these railways, a traction-engine route is under consideration in northeastern Belgian Congo, which will connect the navigable waters of the Congo with those of the Nile.

Many steamers belonging to the government, to commercial companies, or to missions, ply the navigable stretches of the Congo just described. Two of these steamers, between Leopoldville and Stanleyville, are of 500 tons. In addition to the 2,000 miles of the Congo which are navigable, there are about 5,000 miles of navigable tributaries, among which are the Kasai, the Sankuru, the Ubangi, and the Lomami. One may ascend many smaller tributaries of these affluents of the Congo in canoes or whale-boats, Fig. 8.

Interior travel is, however, very largely on foot by caravan-trails, which are broad and usually kept in good condition. Fig. 9 is a view of a suspension-bridge, constructed of vines by the natives, on a caravan-route crossing the Lubefu river, which at this place is 300 ft. wide. Off of these main routes the native trails are often difficult to travel, being narrow, swampy, overgrown with grass, or almost impassable through forest. It is over these trails that one's baggage, supplies, and provisions

are carried by native porters. When they are heavily charged and are expected to carry steadily for a week or more, 12 miles is a good average day's journey, though at times double that distance is made.

The postal service in the Belgian Congo is, all things considered, very satisfactory. There are two main telegraph- and telephone-lines within the colony; one connecting Boma and Coquilhatville, the other Kasongo and Uvira. Cables to Europe usually go to Brazzaville and Loanga in the French Congo.

2. *Labor.*

There is an estimated population in the Belgian Congo of from 12,000,000 to 15,000,000 natives. It seems, therefore, at first sight, that the labor-problem is an easy one, as certainly the major part of the manual labor must be performed by natives. Such, however, is not the case. The black is, as a rule, lazy and perfectly content to allow his wife, or wives, to work in the plantations to insure him the life of idleness that to him is one of luxury and happiness. The dignity and the value of labor are, nevertheless, being slowly taught the native, and as he has by nature a strongly-developed imitative faculty, the labor-problem is by no means hopeless. Clever native carpenters and blacksmiths are seen at many of the State posts, and unusually well-trained Congo men have made excellent clerks and good locomotive-engineers. If properly handled, native labor is not too difficult to obtain in many parts of the colony, and under good head-men, the Congolese is a fairly-efficient manual laborer. For skilled labor and comparatively unimportant clerical work, the Sierra Leone, and particularly the Senegalese, negroes are very satisfactory, as are also the East Coast black men.

The climate greatly handicaps the work of the white man in most parts of the Congo, and in manual labor he can never do more than direct the work of natives. Even with the best of luck in any kind of work, mental or physical, the white man's efficiency, counting illness and the naturally enervating effect of the climate, is cut down to about one-half of what it is in a temperate climate.

The usual term of service in the Belgian Congo is 35 months in the colony and 6 months in Europe, though many of the com-

panies require of their agents but two years in the tropics. Apparently, a man between 25 and 35 years of age stands the life the best. This simply means that a man must be in the best condition, physically and morally, in order to do good work in the African tropics with the least permanent harm to himself.

3. *Timber and Water-Power.*

At the present time, wood is the universal fuel in the Belgian Congo, excepting for driving the locomotives of the Lower Congo railroad. Nearly everywhere, except where the savanna is most characteristically developed, wood for fuel is abundant. For important mining-operations, however, hydro-electrical installations will undoubtedly be used. Wherever the older folded rocks occur, water-falls and rapids are common, and power can be developed in quantity very easily. Fig. 9 is a photographic view of the eastern part of the Pogge chute, on the upper Kasai river. The falls have a head of about 30 ft., and about one-third of the total width is shown in the view. Of all the continents, Africa will benefit most by the perfection of electrical smelting.

4. *Costs.*

It is impossible to give general costs for mining-operations in the Belgian Congo, and the costs in particular cases will vary so radically under changing conditions that any figures that could be given must be of little value. It may, however, be stated that costs are high and that many mineral deposits in the Belgian Congo, at present valueless, would be paying mines in practically any other country.

Transport-costs are excessive. To get machinery into the upper Congo region or the lake country from Antwerp, one must count on at least twice the original cost for transport and customs duty.

A constantly-changing white personnel is an expensive item; for outside of the salary, which is naturally high, each up-country agent is paid at least six months out of his term when he is *en route* to and from Europe. The journey itself is expensive, amounting to about \$1,000 per up-country agent, and his actual living-expenses in the colony come to about \$1,200 per year.

Native labor is comparatively cheap, but it is also compara-

tively inefficient. Two ordinary negroes will sink a pit 2 ft. in diameter in fairly incoherent medium-sized gravels and clay or sand to a depth of from 4 to 6 ft. in a day of 10 hr. A man's pay ranges from 4 to 7 cents per day, plus his food, which costs about 3 cents per day. The wage of a Sierra Leone or Senegal negro ranges from 50 cents to \$1.50 per day, including his food, though the average pay is about 65 cents.

For fresh food the white man must depend largely on goats, sheep, and chickens, which can generally be readily purchased from the natives, along with a few fresh vegetables and fruits. In the dry season game is usually plentiful, and the State posts generally have excellent gardens, from which European vegetables are obtainable. Unfortunately, however, the greater part of the white man's food must be sent out from Europe.

As to the safety of capital invested in the Belgian Congo, that country is much more safe than the average South American republic. Within limited areas revolts may take place, but neighboring tribes cannot set aside their own differences long enough to unite against the white man. Moreover, even where a territory is in revolt, in many instances at least, the white man's property is held sacred. Evidence of the unsavory stories of Congo atrocities published from time to time in American and English newspapers was not seen by us in our two years' journey throughout the Belgian Congo.

The Behavior of Copper-Matte and Copper-Nickel Matte in the Bessemer Converter.

BY DAVID H. BROWNE, COPPER CLIFF, ONTARIO, CAN.*

(Pittsburg Meeting, March, 1910.)

NICKEL has always been a fruitful mother of problems. Previous to the year 1906 nickel was regarded as an element replacing iron in copper-mattes, and it was believed that the same laws which governed the elimination of iron could be applied to nickel. This conception has lately undergone a complete change, and nickel in all its stages is now regarded as an element replacing copper; in other words, copper-nickel is considered now as two elements, but as one metal.

When we commenced our investigations on Monel metal we made a great many experiments on the conversion of mattes, both high copper and high nickel. We studied closely the composition of the mattes and the changes produced by the blow. We found in all cases certain agreements which we believe are due to some law. Briefly stated, our conclusions are as follows:

1. Nickel is not an element replacing iron in matte.
2. Nickel-copper alloys act in the matte-blow like one metal.
3. Nickel-copper alloys follow, during the matte-blow, exactly the same laws as govern the behavior of copper alone.

This brings up the question: What are the laws governing the production of metallic copper, and what are the relations of copper to sulphur and iron during the Bessemer blow?

* Metallurgist of the Canadian Copper Co.

Our knowledge on this source is derived from the published results of Douglas,¹ Van Liew,² Gibb,³ and Mathewson.⁴

Of these, the paper of Mr. Mathewson is the most complete, and will be made the basis of study. He presents a series of analyses of 10-min. samples from three blows of copper at Anaconda, tabulating these results in the form of curves showing the elimination of iron and sulphur in relation to the blowing-time.

Blowing-time depends on many factors—on the grade of the matte, on the amount of matte in the converter, on the condition of the tuyeres, on the volume and pressure of the blast, on the height of the barometer, and so on. Blowing-time is a variable datum-line. Moreover, Mr. Mathewson's paper was entitled, "Relative Elimination of Iron," etc., while the curves give the "rate of elimination," another matter entirely. Consequently, his curves were not comparable either with each other or with the work of others. They could not be superimposed.

In order to get a fixed datum-line, I recalculated all Mr. Mathewson's analyses and expressed the results in "ratios." Taking the percentage of copper in each analysis as 100, the amounts of iron and sulphur are expressed as percentages of the amount of copper present at that time. For example, a matte containing Cu, 46.08; Fe, 24.30; S, 24.70 per cent. becomes Cu, 46.08, with iron ratio 53.8 and sulphur ratio 54.7. The iron in this matte is 53.8 per cent. of the amount of copper. These ratios were plotted in curves, and these curves were found to compare very closely with each other and with the work of other observers.

Tables I., II., III., and the corresponding Figs. 1, 2, 3, show Mr. Mathewson's analyses as given and as recalculated. Table IV. and Fig. 4 show all these analyses grouped according to 5-per cent. rises in the amount of copper. Fig. 4 expresses, therefore, the average of all Mr. Mathewson's results.

¹ The Copper Queen Mine, Arizona, *Trans.*, xxix., 511 to 546 (1899).

² Relative Elimination of Impurities in Bessemerizing Copper-Matte, *Trans.*, xxxiv., 418 to 421 (1904).

³ Discussion of the paper of Mr. Van Liew, *Trans.*, xxxiv., 957 to 963 (1894). The Elimination of Impurities During the Process of Making "Best Selected" Copper, *Proceedings of the Institution of Mechanical Engineers*, April, 1895, p. 254.

⁴ Relative Elimination of Iron, Sulphur, and Arsenic in Bessemerizing Copper-Mattes, *Trans.*, xxxviii., 154 to 161 (1908).

The curve of iron-elimination is a regular mathematical curve, which can doubtless be expressed in a functional equation. This fact, however, pertains to mathematics and not metallurgy;

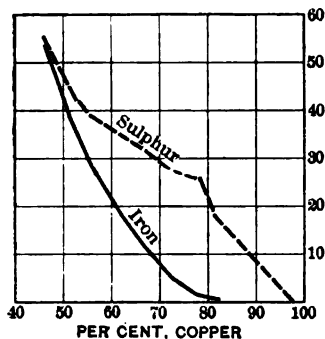


FIG. 1.—MR. MATHEWSON'S TABLE I. ON COPPER BASIS.

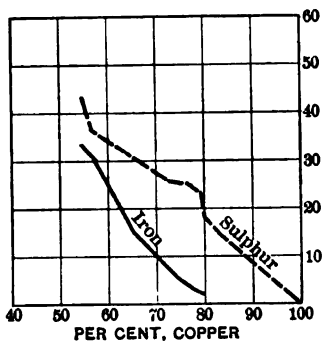


FIG. 2.—MR. MATHEWSON'S TABLE II. ON COPPER BASIS.

for the present it is enough to know that iron slags off with perfect regularity.

On the whole, sulphur disappears in a straight line with a curious jog or reversal occurring when the iron is down to 5 per cent. This will be referred to later.

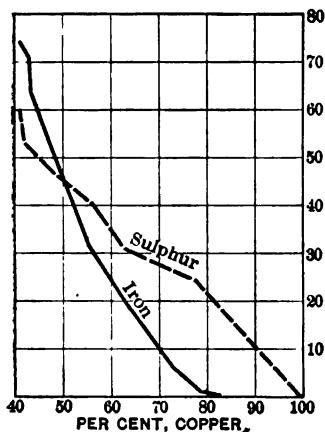


FIG. 3.—MR. MATHEWSON'S TABLE III. ON COPPER BASIS.

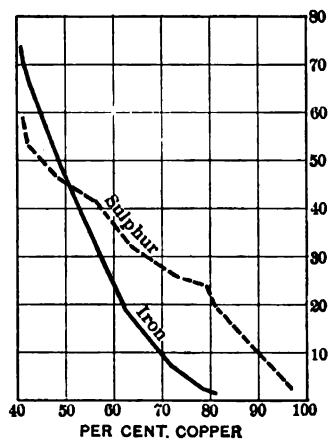


FIG. 4.—MR. MATHEWSON'S TABLES I., II., AND III., COMBINED.

Table V., Fig. 5, and Table VI., Fig. 6, give respectively the results of reverberatory-furnace practice by Mr. Gibb, and Bessemer practice by Mr. Van Liew. The curves are very interesting in showing the parallel nature of two processes.

Douglas's assays, taken simply of the tap, the white metal, and the blister-copper, do not give a curve, but fix several

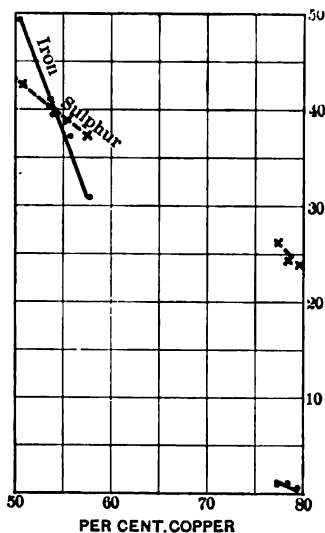


FIG. 4A.—SULPHUR AND IRON RATIOS. DOUGLAS.

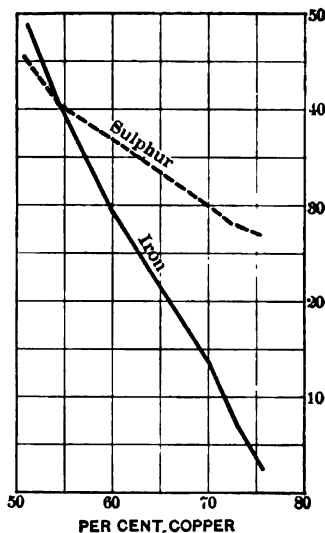


FIG. 5.—SULPHUR AND IRON RATIOS; REVERBERATORY FURNACE. ALLAN GIBB.

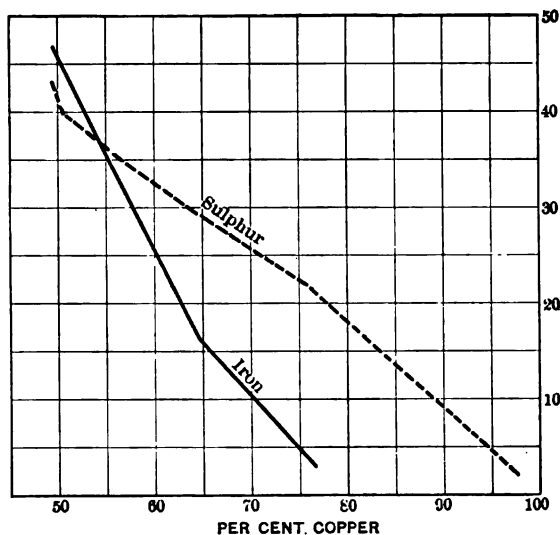


FIG. 6.—SULPHUR AND IRON RATIOS. BESSEMER CONVERTER. W. RANDOLPH VAN LIEW.

valuable reference-points which quite coincide with the curves of all the others, as shown in Fig. 4A. When the results of

these independent observers show such close agreement, it is evident that "relative elimination" is a fixed factor, no matter how much "rate of elimination" or blowing-time may vary. This suggests the idea of the laws governing the action of copper-matte in the Bessemer converter.

Does nickel-matte follow the same laws as copper-matte? This was the problem the Canadian Copper Co. had to solve in 1904. During that year we made very careful tests of a large number of blows, taking samples at intervals of 10 min. during the blow. First we treated matte high in copper and low in nickel, and endeavored to slag the nickel and finish the copper as blister.

Considering the heat of formation, nickel would be expected to follow the iron easily and completely into the slag. Instead of doing so it displays a most extraordinary reluctance to part from the copper, the two metals clinging together in a deathless affinity, so much so that 1 lb. of nickel passing into the slag drags 1.25 lb. of copper with it. Tables VII., VIII., and IX. show the analyses of copper-nickel mattes high in nickel. Tables X., XI., XII., XIII., XIV., and XV. show mattes high in copper. Looking over these data, samples are found of the following composition, which are practically blister-alloy:

	Per Cent.	Per Cent.	Per Cent.
Cu	76.34	84.30	86.90
Ni	21.55	14.35	10.33
CuNi	97.89	98.65	96.23
Fe	0.15	0.40	0.10
S	1.19	0.64	1.04

While nickel during the last stages of the blow does oxidize, yet it lags behind sulphur as a heat-producer. It is impossible to blow all the nickel out. About 2 per cent. is always left in the finished copper.

Tables VII. to XV. show that, even in the most powerful oxidizing conditions we practice, nickel resists oxidation more than its heat-value would indicate.

In attempting to plot these results with copper as a basis no agreement could be observed. Figs. 7A, 8A, 10A, and 15A are given to show how entirely erratic the curves were on this basis. Plotting them on a copper-nickel basis gave remarkable

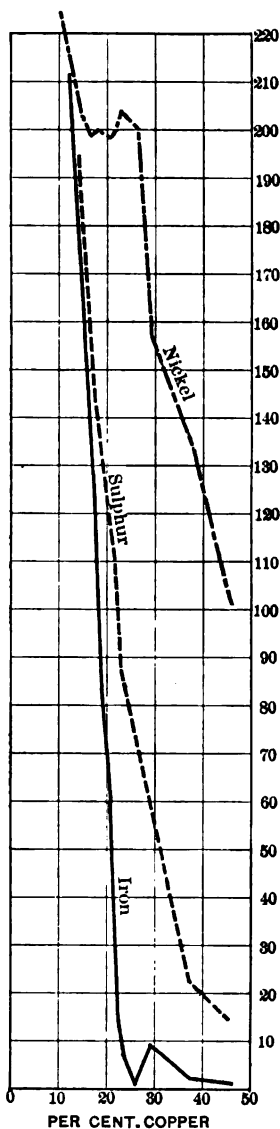


FIG. 7A.—OVERBLOWN COPPER-NICKEL MATTE A. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER = 100.

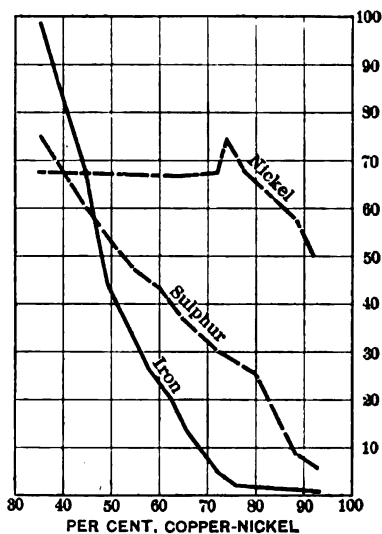


FIG. 7B.—OVERBLOWN COPPER-NICKEL MATTE A. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER-NICKEL = 100.

results. Taking the percentage of copper and nickel together as 100, and reckoning the ratio of iron and sulphur thereto, we obtained perfectly uniform curves, as shown in Figs. 7B, 8B, 9, 10B, 11, 12, 13, and 14.

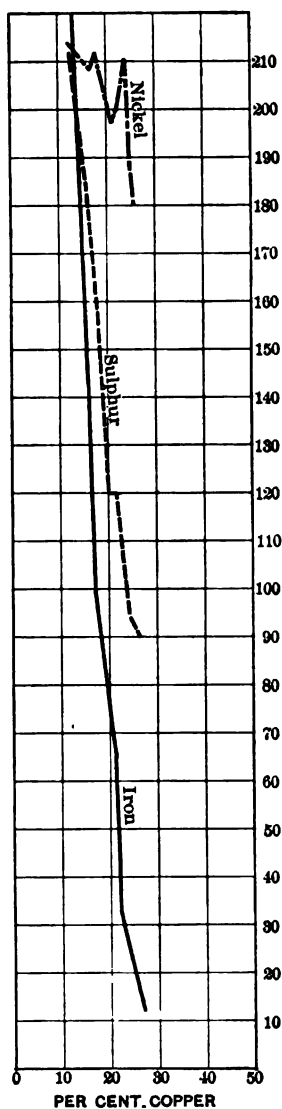


FIG. 8A. — UNDERBLOWN COPPER-NICKEL MATTE B. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER = 100.

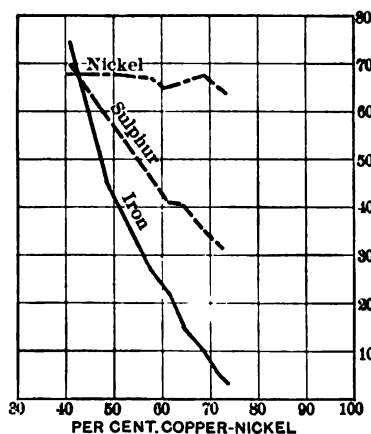


FIG. 8B. — UNDERBLOWN COPPER-NICKEL MATTE B. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER = 100.

Taking an average of these results, the composition and ratios given in Table XV. are obtained. When these data are plotted, as in Fig. 15B, they yield a set of curves which show beyond a

doubt that copper-nickel is the basis of comparison, and that the elimination of sulphur and iron is a direct function of the copper and nickel together and not of either metal separately. (See Figs. 15A and 15B.) A comparison of our curves obtained in this way with those of Douglas, Gibb, and Van Liew shows a striking parallelism. Their data were, however, somewhat meager, and when Mr. Mathewson, in 1907, published his results we welcomed the opportunity to compare his data with those we had obtained in 1904 and 1906.

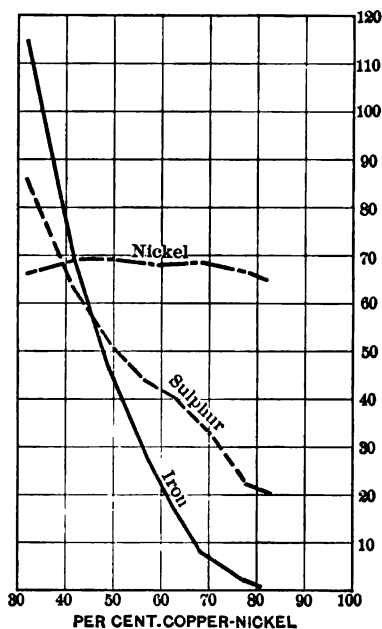


FIG. 9.—ORDINARY COPPER-NICKEL MATTE C. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER-NICKEL = 100.

As previously stated, there was no agreement whatever to be expected from curves based upon blowing-time. When, however, Mathewson's ratios on a copper basis were compared with our ratios on a copper-nickel basis, the curves were not only similar; they were identical. The iron-curves given in Fig. 4, Mathewson's average on copper-mattes, and our average on copper-nickel mattes, can be superimposed with remarkable accuracy, as shown in Fig. 16A.

As nickel sulphide contains more sulphur than copper sulphide, the sulphur-curves are not so closely comparable. They are roughly parallel in the first part of the blow, and coincide after the iron has been eliminated. A curious point of resemblance is the little jog or reversal in the sulphur-

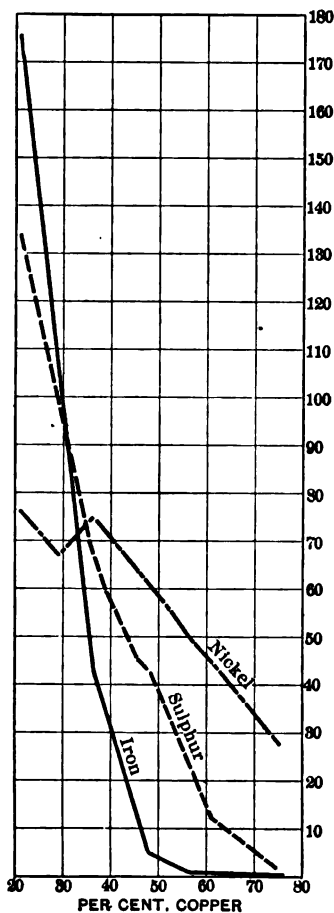


FIG. 10A.—COPPER-NICKEL MATTE D. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER = 100.

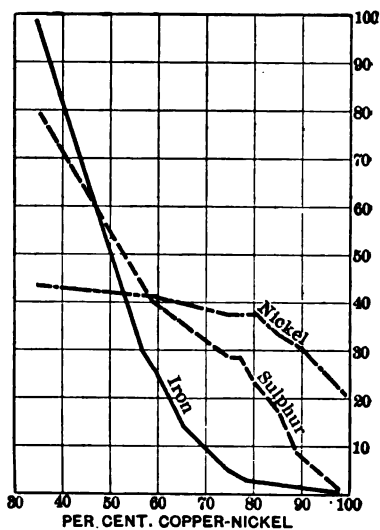


FIG. 10B.—COPPER-NICKEL MATTE D. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER-NICKEL = 100.

curve, which occurs when the iron is reduced to 5 per cent. All the curves of individual blows show this. The only explanation I can offer is that at this point a certain amount of metallic copper or copper-nickel separates out as metal, and, falling to the bottom of the converter, leaves the sulphur with

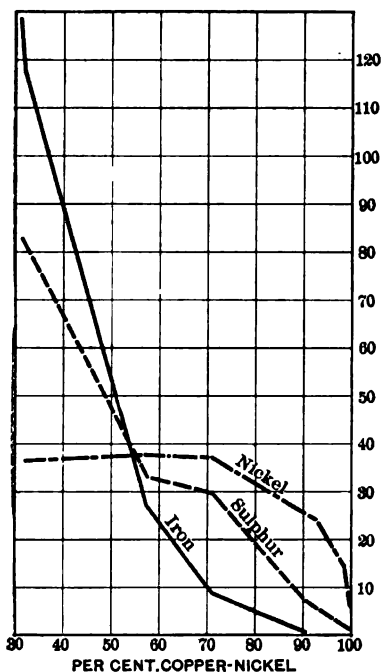


FIG. 11.—COPPER-NICKEL MATTE E. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER-NICKEL = 100.

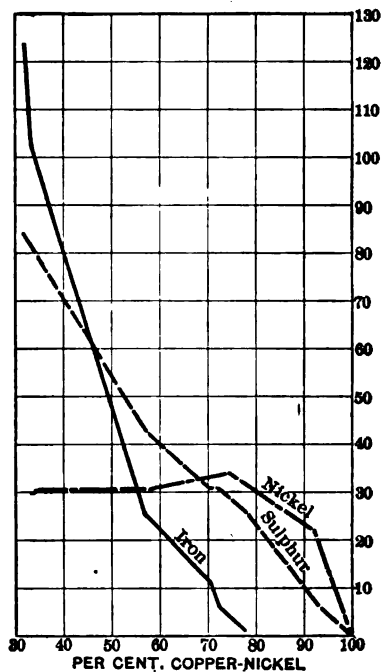


FIG. 13.—COPPER-NICKEL MATTE G. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER-NICKEL = 100.

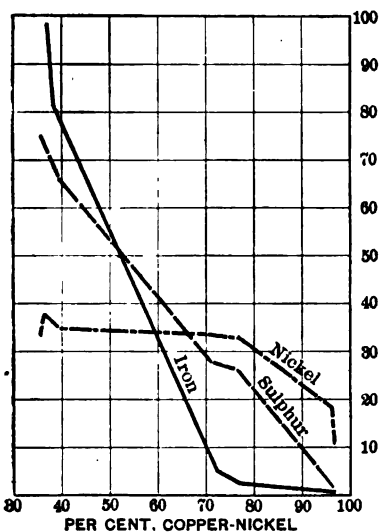


FIG. 12.—COPPER-NICKEL MATTE F. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER-NICKEL = 100.

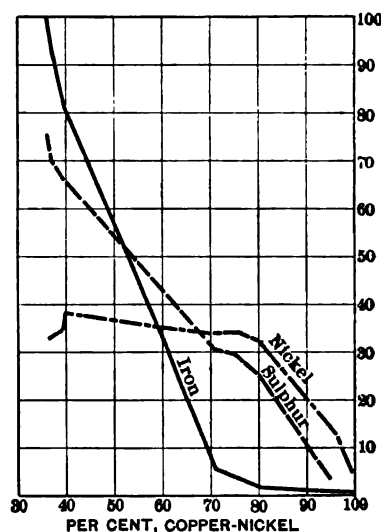


FIG. 14.—COPPER-NICKEL MATTE H. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER-NICKEL = 100.

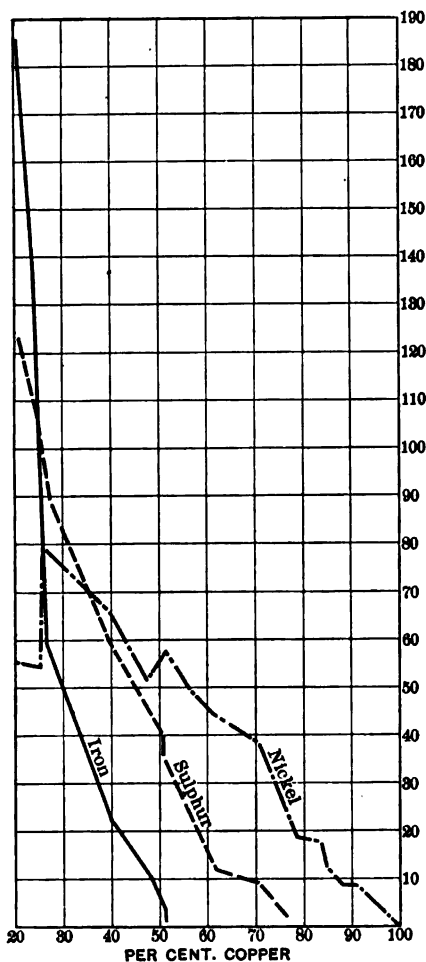


FIG. 15A.—COPPER-NICKEL MATTES D, E, F, G, AND H. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER = 100.

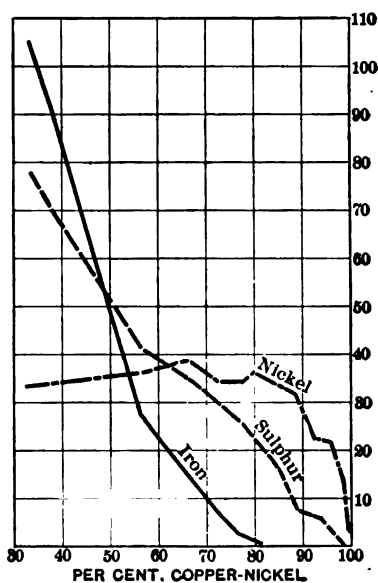
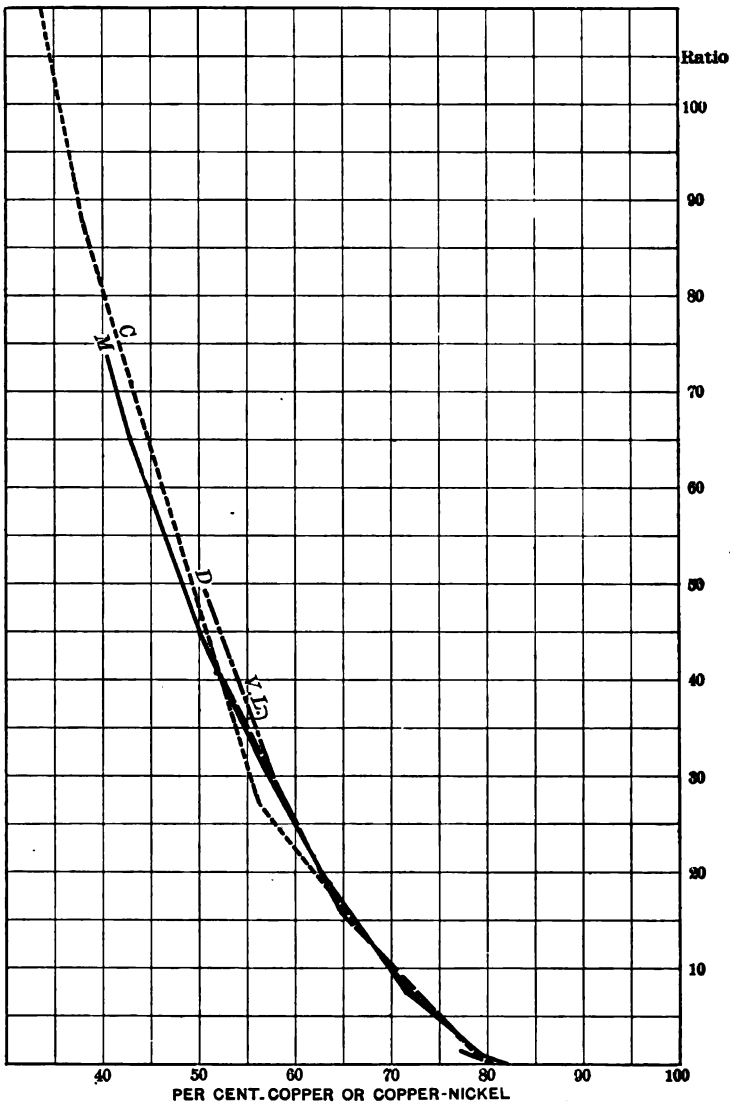


FIG. 15B.—COPPER-NICKEL MATTES D, E, F, G, AND H. RATIOS OF NICKEL, IRON, AND SULPHUR. COPPER-NICKEL = 100.

which it was united to be absorbed by the overlying matte, which makes the matte at this point higher in sulphur than it was before the metal separated out. In order to clear up this matter, I have calculated the sulphur required to form Cu_2S and FeS in all the Anaconda mattes, and the sulphur required to form Cu_2S , Ni_3S_2 , and FeS in our own mattes. After tabulating these results, and deducting the sulphur actually present, the deficiency of sulphur at any point is given. Our own mattes show,

Fig. 18, that the sulphur-deficiency decreases, and between 50 and 75 per cent. of copper-nickel the sulphur is in excess of that

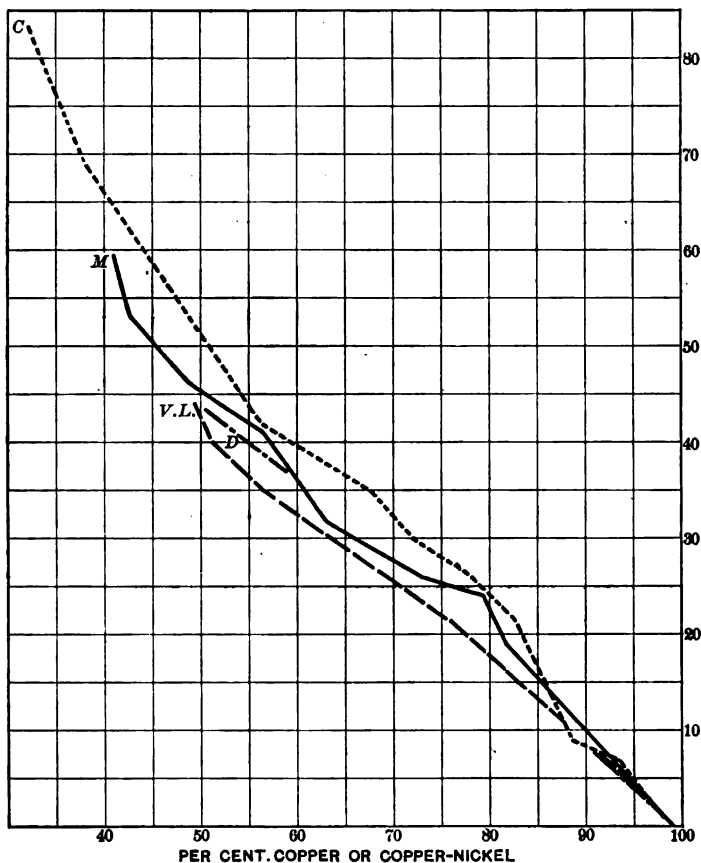


C. Canadian Copper Co. D. Douglas. M. Mathewson. V. L. Van Liew.

FIG. 16A.—IRON RATIOS.

required to unite with the elements. The Anaconda blows, Fig. 17, do not show an excess of sulphur at any point, but they

show a smaller deficiency of sulphur between 55 and 75 per cent. of copper than at other points during the blow, a result which shows that there is the same tendency in both copper- and copper-nickel mattes. An excess of sulphur, or a lessened



C. Canadian Copper Co. D. Douglas. M. Mathewson. V. L. Van Liew.

FIG. 16B.—SULPHUR RATIOS.

deficiency of sulphur, both point to the dropping-out of some metal or alloy in metallic form.

All these coincidences seem to prove that copper-nickel alloys form, as far as conversion is concerned, one homogeneous metal. They act together—no matter what the proportion be; high copper and low nickel, or *vice versa*, they present in

conversion the same curious resistance to oxidation, and their relations towards iron are absolutely similar to the relations of

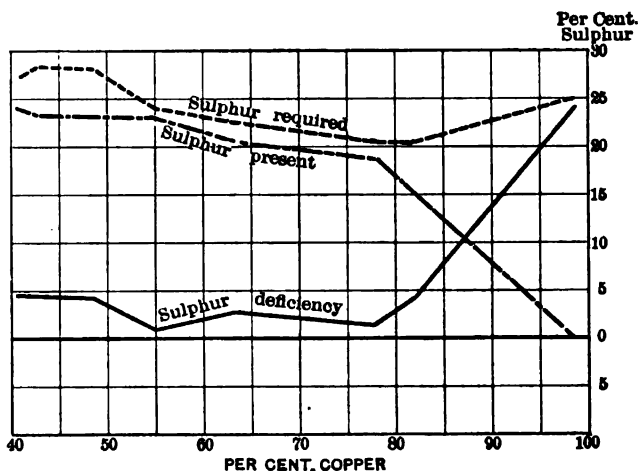


FIG. 17.—SULPHUR RELATIONS OF COPPER-MATTES.

copper alone. Of all such alloys, Monel metal is the one we know most about at present.

This alloy contains about 70 per cent. of nickel and 80 per

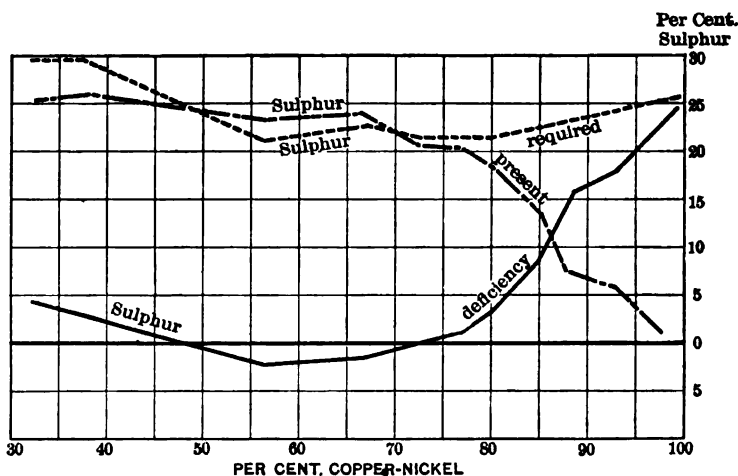


FIG. 18.—SULPHUR-RELATIONS OF COPPER-NICKEL MATTES.

cent. of copper. This proportion is very nearly that in which the two metals exist in the ores of the Canadian Copper Co., and by careful attention to the furnace-charge a Bessemer matte can be produced within 1 per cent. of the required proportion.

The matte is blown till the iron is eliminated, the sulphur is removed by roasting, and the combined oxides reduced to metal. As the compound metals have never been separated from each other, the particles of each seem to be in more intimate contact than can be attained by any synthetic method of manufacture. It seems incredible, but it is a fact, that we have not been able to produce by melting copper and nickel together an alloy having the same physical properties as the alloy produced direct from the matte.

There seems to be some physical reason why nickel and copper cling together in this way, and this resistance to oxidation in the converter is in some way connected with the resistance of the finished alloy to oxidation and corrosion, but what this reason is we do not at present know. A comparison of the properties of copper, nickel, and Monel metal may be of interest.

	Copper, Rolled.	Nickel, Rolled.	Monel Metal.		
			Cast.	Rolled.	Annealed.
Tensile strength, lb. per sq. in.,	34,000	75,500	85,000	100,000	110,000
Elastic limit, lb. per sq. in.,	18,000	21,000	40,000	50,000	80,000
Elongation in 2 in., per cent.,	52	43.9	25	30	25
Contraction, per cent.,	57	57	25	50	50
Melting-point, °C.,	1,084	1,500	1,360		

As before mentioned, the laws governing copper-nickel alloys are not thoroughly understood. The present paper has been in preparation for five years, and is now offered, even though it is imperfect and incomplete, at the request of Mr. Mathewson and others, in the hope that further research may elucidate the thermo-chemical problems involved.

TABLE I.—*Recalculation of Mathewson's Data, Given in His Table I.*

Composition.			Ratios.		
Cu. Per Cent.	Fe. Per Cent.	S. Per Cent.	Cu = 100. Per Cent.	Fe. Per Cent.	S. Per Cent.
46.08	24.30	24.70	46.08	52.7	53.5
46.02	23.70	22.95	46.02	51.5	49.8
51.46	20.50	23.10	51.46	39.8	44.8
53.27	18.70	22.15	53.27	35.0	41.5
56.29	16.20	21.85	56.29	28.7	38.6
59.90	13.70	21.95	59.90	22.8	36.6
62.67	11.40	21.35	62.67	18.2	34.2
67.89	7.60	21.15	67.89	11.2	31.2
73.97	3.40	20.10	73.97	4.6	27.2
77.82	0.90	19.60	77.82	1.5	25.2
74.16	2.60	16.60	74.16	3.5	22.4
81.72	0.20	15.35	81.72	0.3	18.8
98.50	tr.	0.78	98.50	tr.	0.8
98.57	0.01	0.78	(See Fig. 1.)		
99.08	tr.	0.01			

TABLE II.—*Recalculation of Mathewson's Data, Given in His Table II.*

Composition.			Ratios.		
Cu. Per Cent.	Fe. Per Cent.	S. Per Cent.	Cu = 100. Per Cent.	Fe. Per Cent.	S. Per Cent.
54.81	18.00	23.00	54.81	32.8	41.9
56.26	17.40	20.30	56.26	31.0	35.9
38.25	30.10	14.20	38.25	78.6	37.3
64.71	10.40	20.10	64.71	15.2	31.1
68.86	7.40	19.50	68.86	10.7	28.5
72.72	4.20	18.20	72.72	5.8	25.1
78.29	1.60	19.50	78.29	2.04	24.9
79.49	0.50	18.60	79.49	0.63	23.4
78.27	0.90	16.40	78.27	1.13	20.9
79.63	1.00	14.90	79.63	1.25	18.7
82.85	0.80	13.10	82.85	0.9	15.8
98.46	0.019	0.73	98.46	.....	0.8
98.75	0.012	0.53	98.75	.....	0.6
99.26	0.004	tr.	99.26		
			(See Fig. 2.)		

TABLE III.—*Recalculation of Mathewson's Data, Given in His Table III.*

Composition.			Ratios.		
Cu. Per Cent.	Fe. Per Cent.	S. Per Cent.	Cu=100. Per Cent.	Fe. Per Cent.	S. Per Cent.
40.68	29.60	24.30	40.68	72.7	59.7
41.11	29.10	23.50	41.11	70.7	57.2
42.50	27.80	22.70	42.50	65.5	53.4
49.16	23.70	22.60	49.16	48.2	45.9
55.86	17.50	22.90	55.86	31.4	41.1
62.97	12.10	20.40	62.97	19.3	32.4
72.06	5.30	19.10	72.06	7.35	26.5
78.96	0.90	18.70	78.96	1.14	23.7
81.32	0.40	15.90	81.32	0.5	19.5
98.24	0.011	0.81	98.24	tr.	0.8
98.56	0.008	0.86	98.56		
99.17	tr.	0.002	99.17		

(See Fig. 3.)

TABLE IV.—*Recalculation of Mathewson's Data, Combined from His Tables I., II., and III.*

Average Composition.		
Cu. Per Cent.	Fe. Per Cent.	S. Per Cent.
41.33	28.41	23.5
47.41	23.9	23.4
51.18	19.06	22.75
57.08	16.20	21.75
63.85	11.03	20.61
68.37	7.50	20.32
73.22	3.87	18.50
78.84	0.98	18.28
81.73	0.46	14.78
98.51	tr.	0.5

(See Fig. 4.)

NOTE.—Average taken of all analyses with Cu 40 to 45, 45 to 50, etc.

TABLE V.—*Recalculation of Gibb's Data of Reverberatory-Furnace Practice.*

Composition.			Ratios.		
Cu. Per Cent.	Fe. Per Cent.	S. Per Cent.	Cu=100. Per Cent.	Fe. Per Cent.	S. Per Cent.
50.7	25.1	23.3	50.7	49.5	45.9
54.0	22.1	22.1	54.0	40.9	40.9
60.0	17.1	22.1	60.0	28.5	36.8
69.8	9.2	20.9	69.8	13.10	30.0
72.7	5.0	20.5	72.7	6.80	28.0
75.4	1.8	20.4	75.4	2.40	27.0

(See Fig. 5.)

TABLE VI.—*Recalculation of Van Liew's Data of Bessemer-Converter Practice.*

Composition.			Ratios.		
Cu. Per Cent.	Fe. Per Cent.	S. Per Cent.	Cu=100. Per Cent.	Fe. Per Cent.	S. Per Cent.
49.72	23.31	21.28	49.72	46.5	43.0
50.20	23.15	20.99	50.20	46.1	40.0
56.88	17.85	19.74	56.88	31.40	34.60
64.60	10.50	18.83	64.60	16.30	29.0
76.37	2.40	16.30	76.37	3.10	21.30
99.12	0.038	0.15	99.12	0.03	0.15

(See Fig. 6.)

TABLE VII.—*Composition of Copper-Nickel Matte A. High Nickel.*

(Sampled at 10-min. intervals during the blow.)

Composition.					Ratios.				Ratios.			
Cu Per Cent.	Ni. Per Cent.	CuNi. Per Cent.	Fe. Per Cent.	S. Per Cent.	Cu = 100. Per Cent.	Ni. Per Cent.	Fe. Per Cent.	S. Per Cent.	CuNi = 100. Per Cent.	Ni. Per Cent.	Fe. Per Cent.	S. Per Cent.
11.40	23.72	35.12	34.75	26.54	11.40	224.4	316	249	35.12	67.6	98.9	75.6
14.30	29.04	43.34	26.27	26.68	14.30	203	184	186	43.34	67.0	60.8	61.6
16.55	32.96	49.51	21.20	26.62	16.55	199	128	161	49.51	66.7	42.8	58.7
18.85	37.54	56.39	15.61	26.02	18.85	200	83	138	56.39	66.3	27.6	46.0
20.60	40.46	61.06	12.84	25.68	20.60	196	59.8	124	61.06	66.2	20.2	42.1
21.65	43.32	64.97	8.87	23.88	21.65	200	41	110	64.96	66.7	13.7	36.8
22.95	50.64	73.59	3.11	21.72	22.95	231	13.5	94.7	73.59	68.7	4.2	29.4
20.20	54.38	74.58	2.75	20.18	20.20	261	13.7	100	74.58	73	3.7	27.1
23.60	53.36	76.96	1.68	20.70	23.60	226	6.8	87.3	76.96	69.2	2.2	26.8
26.30	52.48	78.78	0.45	20.18	26.30	200	1.71	76.6	78.78	66.5	0.5	25.6
29.80	46.12	75.42	2.65	20.98	29.80	157	9.0	71.6	75.42	61.2	3.4	27.8
37.05	50.98	88.03	0.96	8.38	37.05	137	2.6	22.6	88.03	58	1.1	9.5
45.90	46.50	92.40	0.56	6.52	45.90	101	1.2	14.2	92.40	49.9	0.6	7.0

(See Fig. 7A.) (See Fig. 7B.)

TABLE VIII.—*Composition of Copper-Nickel Matte B. High Nickel.*
(Sulphur by Difference.)

(Sampled at 10-min. intervals during the blow.)

Composition.					Ratios.				Ratios.			
Cu.	Ni.	CuNi.	Fe.	S.	Cu	Ni.	Fe.	S.	CuNi	Ni.	Fe.	S.
Per	Per	Per	Per	Per	=100.	Per	Per	Per	=100.	Per	Per	Per
Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.
12.98	27.80	40.53	30.5	27.6	12.93	213	285	211	40.53	68	75.2	68.0
15.66	33.00	48.66	22.54	28.89	15.66	210	143	184	48.66	67.9	46.3	59.7
17.32	36.02	53.34	19.0	27.66	17.32	209	109	159	53.34	67.3	35.6	52.7
18.06	38.26	56.34	16.36	27.81	18.06	211	90	151	56.34	67.5	27.1	48.4
20.86	40.12	60.98	13.75	25.23	20.86	197	65	120	60.98	65.8	22.4	41.1
21.41	42.98	64.39	9.90	25.73	21.41	200	46	120	64.39	66.7	15.7	39.8
22.02	46.66	68.68	7.40	24.92	22.02	211	33	113	68.68	67.9	10.8	36.4
24.80	47.14	71.94	4.50	23.66	24.80	190	13	95	71.94	65.3	6.24	32.6
26.26	46.90	73.16	3.15	23.69	26.26	178	12	90	73.16	64	4.3	32.4

(See Fig. 8A.)

(See Fig. 8B.)

TABLE IX.—*Composition of Copper-Nickel Matte C. High Nickel.*

(Sampled at 10-min. intervals during the blow.)

Composition.					Ratios.			
Cu.	Ni.	CuNi.	Fe.	S.	CuNi = 100.	Ni.	Fe.	S.
Per	Per	Per	Per	Per	Per	Per	Per	Per
Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.
10.55	21.60	32.15	37.25	27.70	32.15	67.2	11.58	86.2
12.80	28.50	41.30	28.60	26.25	41.30	69	69.2	63.5
15.40	34.00	49.40	21.70	25.95	49.40	68.9	43.9	52.5
18.10	39.80	57.90	14.95	25.95	57.90	68.3	25.8	44.5
19.80	43.25	63.05	10.30	25.10	63.05	68.6	16.3	39.8
21.60	46.85	68.45	5.57	25.04	68.45	68.4	8.1	35.1
25.90	52.20	78.10	2.15	17.70	78.10	68.9	2.7	22.6
28.10	53.4	81.5	1.07	16.10	81.5	65.5	1.3	20.0

(See Fig. 9.)

TABLE X.—*Composition of Copper-Nickel Matte D. High Copper.*

(Sampled at 10-min. intervals during the blow.)

Composition.					Ratios.				Ratios.			
Cu.	Ni.	CuNi.	Fe.	S.	Cu.	Ni.	Fe.	S.	CuNi	Ni.	Fe.	S.
Per	Per	Per	Per	Per	=100.	Per	Per	Per	=100.	Per	Per	Per
Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.
Tap..20.15	15.65	35.80	32.20	26.92	20.15	76.0	175	134	35.80	43.7	98	77.7
Con..39.72	26.75	66.47	8.95	23.84	39.72	66.3	22	60	66.47	39.6	13.2	35.4
Tap..20.75	13.70	34.45	36.0	27.10	20.75	64.0	173	131				
Con..36.04	23.00	59.04	15.67	24.71	36.04	74.2	43.6	68.8	59.04	40.7	26.2	41.8
Con..47.96	29.13	77.09	2.46	20.74	47.96	60.8	5.0	43.2	77.09	37.8	3.18	26.9
Tap..21.66	12.40	34.05	37.00	27.08	21.66	57.1	171	125				
Con..35.34	21.15	56.49	16.80	26.15	35.34	59.3	47.2	70.8	56.49	37.7	29.7	44.4
Con..47.26	28.25	75.51	3.22	21.43	47.26	59.9	6.8	45.2	75.51	37.4	4.24	28.3
Con..51.23	29.51	80.74	0.55	18.32	51.23	57.6	1.0	35.6	80.74	37.2	0.68	22.6
Con..56.40	28.49	84.89	0.47	13.31	56.40	50.3	0.83	24.4	84.89	33.5	0.55	16.2
Con..61.22	27.77	88.99	0.25	7.60	61.22	45.1	0.40	12.4	88.99	31.1	0.3	8.6
Con..76.34	21.55	97.89	0.15	1.19	76.34	23.1	0.20	1.56	97.89	22.0	tr.	1.2

(See Fig. 10A.)

(See Fig. 10B.)

TABLE XI.—*Composition of Copper-Nickel Matte E. High Copper.*

Composition.						Ratios.				Ratios.			
Cu. Per Cent.	Ni. Per Cent.	CuNi. Per Cent.	Fe. Per Cent.	S. Per Cent.		Cu= 100. Per Cent.	Ni. Per Cent.	Fe. Per Cent.	S. Per Cent.	CuNi =100. Per Ct.	Ni. Per Ct.	Fe. Per Ct.	S. Per Ct.
Tap...20.60	11.80	32.4	38.35	27.36		20.60	57.25	186	193	32.4	36.7	118	34.5
Tap...20.80	10.85	31.15	39.5	27.4		20.80	58.8	194	135	31.15	34.8	127	31.8
Tap...20.80	12.05	32.85	.....	.....		20.80	57.4	.....	.....	32.85	36.8		
Con...36.05	21.45	57.50	15.20	19.55		36.05	59.5	42.15	53.1	57.50	37.4	26.4	34
Con...45.28	26.15	71.43	5.50	21.24		45.28	57.7	12.15	46.9	71.43	36.8	7.7	29.8
Con...70.20	22.60	92.80	0.20	7.15		70.20	32.2	0.28	10.17	92.80	24.4	0.22	7.7
Con...84.30	14.85	98.65	0.40	0.64		84.30	17.0	0.47	0.76	98.65	14.5	0.41	0.7
Con...90.90	8.00	98.90	0.10	1.18		.....	.....	.....	.....	98.90	8.1	tr.	1.2

(See Fig. 11.)

TABLE XII.—*Composition of Copper-Nickel Matte F. High Copper.*

(Sampled at 10-min. intervals during the blow.)

Composition.						Ratios.				Ratios.			
Cu. Per Cent.	Ni. Per Cent.	CuNi. Per Cent.	Fe. Per Cent.	S. Per Cent.		Cu= 100. Per Cent.	Ni. Per Cent.	Fe. Per Cent.	S. Per Cent.	CuNi =100. Per Ct.	Ni. Per Ct.	Fe. Per Ct.	S. Per Ct.
Tap...25.70	13.57	39.27	32.45	26.15		25.70	52.7	126.1	101.3	39.27	34.8	82.5	66.5
Con...47.15	23.32	70.47	5.30	21.05		47.15	50.3	11.4	45.4	70.47	33.1	7.5	28.5
Tap...24.80	13.85	38.65	33.0	26.12		24.80	55.7	132.5	104.7	38.65	36.0	85.5	68
Con...47.35	23.32	70.67	6.0	20.90		47.35	49.2	12.7	44.0	70.67	33.0	8.5	29.8
Tap...24.10	12.25	36.35	35.20	26.56		24.10	50.9	146.2	110.5	36.35	33.5	98.0	73.0
Con...49.9	23.7	73.6	4.3	22.26		49.9	47.5	8.8	44.5	73.6	32.7	5.9	31.1
Con...51.95	25.0	76.95	1.97	19.64		51.95	48.0	3.78	37.75	76.95	32.4	3.6	26.4
Con...78.32	18.77	97.09	0.65	2.21		78.32	23.9	0.83	2.82	97.09	19.4	0.7	2.2
Con...88.7	7.78	96.48	0.55	1.10		88.7	8.79	0.62	1.13	96.48	8.0	0.6	1.2
Con...86.90	10.33	97.23	0.10	1.04		.....	.....	.....	.....	97.23	10.6	0.1	1.1

(See Fig. 12.)

TABLE XIII.—*Composition of Copper-Nickel Matte G. High Copper.*

(Sampled at 10-min. intervals during the blow.)

Composition.						Ratios.				Ratios.			
Cu. Per Cent.	Ni. Per Cent.	CuNi. Per Cent.	Fe. Per Cent.	S. Per Cent.		Cu= 100. Per Cent.	Ni. Per Cent.	Fe. Per Cent.	S. Per Cent.	CuNi =100. Per Ct.	Ni. Per Ct.	Fe. Per Ct.	S. Per Ct.
Tap...23.10	10.13	33.23	37.80	26.74		23.10	43.7	164	116	33.23	30.8	113	30.5
Con...46.60	23.45	70.05	7.26	22.28		46.60	50.3	15.5	49.2	70.05	33.5	108	31.8
Tap...22.60	9.26	31.86	38.8	26.6		22.60	41.0	172	118	31.86	29.1	122	33.5
Con...39.20	17.70	56.90	14.95	24.42		39.20	42.6	38.1	62.2	56.90	31.2	26.6	43
Con...47.80	24.15	71.95	5.20	22.50		47.80	50.8	10.87	47.1	71.95	33.9	7.2	31.6
Con...53.75	24.80	78.55	0.75	20.26		53.75	46.3	1.39	42.0	78.55	31.6	0.9	25.8
Con...72.72	20.95	93.67	0.11	5.65		72.72	30.2	0.15	7.78	93.67	22.4	0.13	6.0
Con...98.30	0.85	99.15	0.12	0.51		98.30	0.86	0.12	0.52	99.15	1.1	0.12	0.5

(See Fig. 13.)

TABLE XIV.—*Composition of Copper-Nickel Matte H. High Copper.*

(Sampled at 10-min. intervals during the blow.)

Composition.						Ratios.				Ratios.			
Cu. Per Cent.	Ni. Per Cent.	CuNi. Per Cent.	Fe. Per Cent.	S. Per Cent.		Cu =100. Per Cent.	Ni. Per Cent.	Fe. Per Cent.	S. Per Cent.	CuNi =100. Per Cent.	Ni. Per Cent.	Fe. Per Cent.	S. Per Cent.
Tap...25.20	14.80	40.0	32.0	26.0		25.20	58.7	126.9	103.2	40.0	37	80	65
Con...46.95	24.46	71.41	4.90	21.76		46.95	52.1	10.4	46.3	71.41	34.4	6.8	30.5
Tap...25.80	13.79	39.59	32.25	26.10		25.80	58.2	124.6	100.8	39.59	35	82	66
Con...49.95	24.74	74.69	4.0	21.74		49.95	49.3	7.99	43.37	74.69	33.2	5.3	29
Tap...24.80	12.64	37.44	34.25	26.25		24.80	50.8	137.8	103.6	37.44	33	92	70
Con...48.75	25.89	74.64	3.57	21.15		48.75	51.0	7.3	43.3	74.64	34.8	4.8	28.5
Tap...23.90	11.87	35.77	35.70	26.62		23.90	49.6	148.8	111.2	35.77	33.5	100	75
Con...54.50	25.12	79.62	1.10	20.80		54.50	46.10	2.02	56.7	79.62	32	1.4	25.2
Con...84.90	11.75	96.65	0.61	0.95		84.90	13.8	0.72	1.12	96.65	12.8	0.7	1.0
Con...92.3	4.65	96.95	0.26	0.49						(See Fig. 14.)			
Con...97.38	1.79	99.17	0.48	0.33		97.38	1.84	0.49	0.34				

TABLE XV.—*Composition of Copper-Nickel Mattes D, E, F, G, H, Combined. High Copper.*

Composition.					Ratios.				Ratios.			
Cu. Per Cent.	Ni. Per Cent.	CuNi. Per Cent.	Fe. Per Cent.	S. Per Cent.	Cu =100. Per Cent.	Ni. Per Cent.	Fe. Per Cent.	S. Per Cent.	CuNi =100. Per Cent.	Ni. Per Cent.	Fe. Per Cent.	S. Per Cent.
20.50	11.86	31.86	37.91	25.42	20.50	55	185	124	31.86	34.40	115	77
24.56	13.30	37.86	33.76	26.34	24.56	54	133	107	37.86	35.20	91.7	69.3
26.19	20.82	57.01	15.56	23.46	26.19	79	59	89	57.01	37.2	27.9	41.9
40.72	26.75	67.47	8.95	23.84	40.72	65	22	58	67.47	39.6	18.2	35.4
47.64	24.32	71.96	5.06	21.72	47.64	51	10	46	71.96	33.8	7.02	30.2
51.08	26.46	77.54	1.90	20.34	51.08	51	3	39	77.54	34.1	2.45	26.3
51.23	29.51	80.74	0.55	18.32	51.23	57	1	35	80.74	36.6	0.68	22.7
56.40	28.49	84.89	0.47	18.81	56.40	50	...	24	84.89	38.6	0.55	16.25
61.22	27.77	88.99	0.25	7.60	61.22	45	...	12	88.99	31.2	0.28	8.52
71.46	21.77	93.23	0.16	6.40	71.46	38	...	9	93.23	23.4	0.17	6.87
76.34	21.55	97.89	0.15	1.19	76.34	28	...	1.5	97.89	21.9	0.15	2.12
84.30	14.35	98.65	0.40	0.64	84.30	17	...	.....	98.65	14.5	0.41	0.65
91.10	7.65	98.75	0.10	1.37	91.10	8	...	.....	98.75	7.72	0.10	1.38
78.22	18.77	97.99	0.65	2.21	78.22	24	...	.....	97.99	19.07	0.67	2.26
88.70	7.78	96.48	0.55	1.00	88.70	8	...	.....	96.48	8.06	0.56	1.02
88.29	8.72	97.01	0.71	1.17	88.29	9	...	.....	97.01	9.0	0.73	1.21
84.90	11.75	96.65	0.61	0.95	84.90	13	...	.....	96.65	12.5	0.63	0.98
98.30	0.85	99.15	0.12	0.51	98.30	0.9	...	.....	99.15	0.86	0.12	0.52
97.38	1.79	99.17	0.48	0.33	97.38	1.8	...	.....	99.17	1.79	0.48	0.33
					(See Fig. 15A.)				(See Fig. 15B.)			

The Fushun Colliery, South Manchuria.

BY WARDEN A. MOLLER, TIENTSIN, CHINA.

(Pittsburg Meeting, March, 1910.)

THE Fushun coal-field, now being opened up by the South Manchurian Railway Co., is connected with the main line by a branch, 30 miles long, from Sui Chia Tun, 10 miles south of Mukden, the capital of Manchuria.

The coal-field, which lies on the southern bank of the Hun river, 25 miles east of Mukden, consists of a long narrow valley, running east and west between hills composed of granitic and volcanic rocks. At the foot of the northern hills, the Hun river flows westward towards the Liao river, which drains the greater part of South Manchuria. At the foot of the southern hills, resting immediately upon volcanic rocks, and overlain by 20 ft. of alluvial, is a thick layer of Tertiary shales, carrying near the base two coal-seams. In many places the lower of these two seams is in immediate contact with volcanic lavas and basalts, the flows of which were evidently both prior and subsequent to the formation of the coal-seams. This contact has practically destroyed the lower seam for commercial purposes. The value of the field lies in the upper seam, which, for a length of nearly 8 miles, varies from 100 to 180 ft. thick. Of this seam, 85 per cent. is good coal.

The seam dips to the north conformably with the shales, at angles of from 25° to 30°, and appears to have an uninterrupted dip for about 1.5 miles before being possibly cut off by the northern hills.

The coal-bearing shales extend east and west for a length of about 20 miles, but towards the east the continuity of the seams is broken by intrusive rocks.

The coal is of the sub-bituminous variety, low in ash, bright in appearance, and breaks with a conchoidal fracture. It has the usual qualities of Tertiary coal—quick steam-raising and poor stacking-qualities. Pieces of resin, varying in size from

a pinhead to a pea, are frequently found imbedded in the coal.

The following analyses have been made from samples of the thick seam :

Fixed Carbon.	Volatile Hydro-carbons.	Moisture.	Ash.	Sulphur.
Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
44.7	42.6	6.7	5.6	0.4
51.0	41.1	4.4	2.9	0.6
57.7	33.7	6.2	2.0	0.4

In practice, the quantity of ash and unburnt coal varies from 7 to 10 per cent.; the moisture-content of the freshly-mined coal is somewhat larger than that given above, owing to the delay between the picking of the sample and its analysis. Before the Russo-Japanese war, the field had been worked in only a desultory manner, due chiefly to official interference on account of the proximity to the Imperial Manchurian tombs. For many years both Koreans and Chinese have at different times unofficially mined coal for local consumption. The principal use of coal in Manchuria was for blacksmith's work, which required a higher class of fuel. Moreover, the Fushun coal could not compete with the semi-bituminous and coking-coals of the Yentai and Pen Hsi Hu fields.

At present the Fushun field has been proved to contain an enormous tonnage per acre comparatively near the surface, so that coal can be mined and sold at such a low price as to counteract the somewhat low economy of the fuel itself, especially since its low ash makes it a fair fuel for long locomotive-runs.

The present production, about 1,600 tons per day, is raised from a series of shallow pits, sunk during and subsequent to the Russo-Japanese war. The management, in order to increase the tonnage to 5,000 tons per day, is now sinking two pairs of shafts, of 18 and 20 ft. diameter respectively, a mile apart, and laying out surface-works and town-site on a corresponding scale.

The pair of shafts most advanced, named the O'Yama, have up to date presented no difficulties; at present they are 370 ft. deep, and are entirely in green and gray shales, which have been proved by bore-holes to continue the entire depth. So far the shafts are practically dry, and coal is expected to be reached

at a depth of 1,200 ft. The shafts, lined with brick laid in cement, will probably be completed about the end of the year 1909.

The Toge shafts, 1 mile to the east, have just been commenced. The intention of the management is to provide all power, except for winding and ventilation, from a central electric power-plant; already there have been installed in a capacious brick and steel power-house two 500-kw. Parsons turbine-driven dynamos, which supply three-phase current at 2,000 volts. Preparations are being made to erect two similar 1,000-kw. machines.

Steam is supplied to the engines around the O'Yama shafts by a battery of Babcock & Wilcox boilers, provided with a chain stoker and an automatic ash-remover; steam-pressure at 160 lb. per sq. in. is superheated 100° C., and feed-water for the boilers is passed through a set of Green's economizers.

The water for the town-site, boiler-consumption, and condensers is supplied from the river by an electric-driven turbine-pump, capable of raising 600 gal. per min. against a head of 150 feet.

The machine-, blacksmith-, and carpenter-shops, and air-compressor plant, are supplied with power from standard 25-kw. motors, which obviates the storage of a multitude of spare parts.

The town-site is being laid out on a liberal scale, and 50 or more two-story brick houses have already been erected for the higher class Japanese employees, including large offices, a school, a club, a company store, and free baths. The building of a hotel and a theater is in contemplation. The houses are heated by a central steam-plant, and are equipped with electric light, telephones, and hot and cold water.

The laboring class, which will probably amount in number to 3,000 Japanese and 10,000 Chinese, are housed in rows of houses suitable to each nationality.

The doubling of the present single-track main line between Sui Chia Tun and Tairen will be completed by the end of 1909. The ports for export will be Newchuang and Tairen, situated respectively 130 and 270 miles south of the coal-field. Tairen is about 15 miles northeast of Port Arthur.

**Proceedings of the Ninety-Eighth Meeting, Pittsburg, Pa.,
March, 1910.**

COMMITTEES.

LOCAL COMMITTEE.—R. C. Crawford, *Chairman*; Harrison W. Craver, *Secretary*; Julian Kennedy, Taylor Allderdice, E. W. Pargny, Charles L. Miller, W. H. Rea, S. A. Taylor, M. E. Wadsworth, W. M. Henderson, A. C. Dinkey, W. L. Jones, E. L. Messler, George Mesta, J. H. Jones, G. H. Riley, S. L. Goodale, D. W. McNaugher.

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The Institute Headquarters was established at the Hotel Schenley, where a bureau of information was maintained for the benefit of the visiting members and guests of the party during the time of the meeting.

TECHNICAL SESSIONS.

The first session, held Tuesday evening, Mar. 1, 1910, in the large lecture hall of the Carnegie Institute, was called to order by Harrison W. Craver, Secretary of the Local Committee. Mr. Craver introduced Dr. John A. Brashear, who extended to the members and guests a hearty welcome to the city of Pittsburg, to which David W. Brunton, President of the Institute, responded.

The following papers were presented in oral abstract by the authors:

Biographical Notice of Dr. Charles B. Dudley, by Dr. R. W. Raymond, New York, N. Y.

Biographical Notice of William Metcalf, by Col. H. P. Bope, Pittsburg, Pa.

Development of Hindered Settling Apparatus, by Robert H. Richards, Boston, Mass. (Illustrated by lantern-slides.)

A Few Mining Districts in the Argentine Republic, South America, by Z. S. Beyl. (Illustrated by lantern-slides.)

The second session of the Institute, held at the same place, Wednesday morning, March 2, was called to order by President Brunton.

The following papers were presented in oral abstract by the authors:

Systematic Exploitation in the Pittsburg Coal-Seam, by F. Z. Schellenberg and Edward McGrew, Pittsburg, Pa. Discussed by Frank W. De Wolf, Urbana, Ill.

*A Commercial Fuel-Briquette Plant, by William H. Blauvelt, Syracuse, N. Y. Discussed by C. T. Malcolmson, Chicago, Ill.; E. W. Parker, Washington, D. C.; and John Birkinbine, of Philadelphia, Pa.

*Dust-Explosions in Coal-Mines, by George Samuel Rice, Pittsburg, Pa.

The Gaseous Decomposition-Products of Black Powder, by C. M. Young, Lawrence, Kan.

Work of the Technologic Branch of the U. S. Geological Survey at Pittsburg, Pa., by Joseph A. Holmes, Washington, D. C.

The third session of the Institute, held at the same place, Wednesday evening, March 2, was called to order by President Brunton.

The following papers were presented in oral abstract by the authors:

The Conditions of Accumulation of Petroleum in the Earth, by David T. Day, Washington, D. C.

The School of Mines at the Pittsburg University, by M. E. Wadsworth, Pittsburg, Pa.

The Technical Schools of the Carnegie Institution, by Fred Crabtree, Pittsburg, Pa.

A New Method of Cyaniding Gold- and Silver-Ores, by E. Gybbon Spilsbury, New York, N. Y.

The Dwight and Lloyd Sintering-Process, by Arthur S. Dwight, New York, N. Y. (Illustrated by lantern-slides.)

The fourth and concluding session, held at the same place, Friday morning, March 4, was called to order by President Brunton.

The following papers were presented in oral abstract by the authors :

The Huronian as a Gold-bearing Terrane, by Robert Bell, Ottawa, Can.

The Action of Explosives in Rocks of Different Degrees of Hardness, by W. O. Snelling, Pittsburg, Pa.

Introduction of the Basic-Steel Process in the United States, by George W. Maynard, New York, N. Y.

Electric Mine-Hoists, by David B. Rushmore and Karl A. Pauly, Schenectady, N. Y. (Illustrated by lantern-slides.)

Field-Investigations of Structural Materials, by E. F. Burchard, Washington, D. C.

Coal- and Iron-Ore in Western Oaxaca, Mexico, by J. L. W. Birkinbine, Mexico City, Mexico.

The Chemical Control of Slimes, by Harrison E. Ashley, Pittsburg, Pa.

In addition to the papers already noted, the following were read by title for future publication :

Combustion in Cement-Burning, by Byron E. Eldred, New York, N. Y.

*A Method of Calculating Sinking-Funds, and a Table of Values for Ordinary Periods and Rates of Interest, by John B. Dilworth, Philadelphia, Pa.

*Cyanide Plant and Practice at the Minas del Tajo, Rosario, Sinaloa, Mexico, by George A. Tweedy and Roger L. Beals, Rosario, Sinaloa, Mexico.

The Copper-Provinces of the United States, by William H. Emmons, Chicago, Ill.

*The Behavior of Copper-Slags in the Electric Furnace, by Lewis T. Wright, San Francisco, Cal.

Chemical Laboratories in Iron- and Steel-Works, by George W. Maynard, New York, N. Y.

Notes on Field Methods of Assaying, *i. e.*, an Assay-Shop in an Ordinary Valise, by S. K. Bradford, National, Nev.

*The Girod Electric Furnace, and the French Works Using the Paul Girod Steel-Process, by Wilhelm Borchers, Aachen, Germany.

Electricity in Mines, by William Kelly, Vulcan, Mich.

* Distributed in printed form.

*A New Separator for the Removal of Slate from Coal, by W. S. Ayres, Hazleton, Pa.

Improvements in Blast-Roasting, by Herbert Haas, San Francisco, Cal.

Ultimate Source of Ores, by Charles R. Keyes, Des Moines, Iowa.

*The Genesis of the Leadville Ore-Deposits, by Max Boehmer, Denver, Colo.

Heats of Formation of Some Ferro-Calcic Singulo-Silicates, by H. O. Hofman and C. Y. Wen, Boston, Mass.

*Professional Ethics, by R. W. Raymond, New York, N. Y.

*Application of Descriptive Geometry to Mining-Problems, by Joseph W. Roe, New Haven, Conn.

*The Behavior of Copper-Mattes and Copper-Nickel Mattes in the Bessemer Converter, by D. H. Browne, Copper Cliff, Ontario, Canada.

*Mining-Conditions in the Belgian Congo, by Sydney H. Ball, New York, N. Y., and Millard K. Shaler, Lawrence, Kan.

*Sampling Anode-Copper, with Special Reference to Silver-Content, by William Wraith, Anaconda, Mont.

The Giroux Shaft, by C. Everard Arnold, Kimberly, Nev.

Deacidifying Furnace-Gases, by F. T. Havard, Madison, Wis.

*The Combustion-Temperature of Carbon and Its Relation to Blast-Furnace Operation, by Clarence P. Linville, State College, Pa.

*The Fushun Colliery, South Manchuria, by Warden A. Moller, Tientsin, China.

Federal Coal-Mines in the Philippines, by Oscar H. Reinholdt, Pasadena, Cal.

*Professional Ethics, by Victor G. Hills, Denver, Colo.

Discussion of the paper of Audley H. Stow, Pressure-Fans vs. Exhaust Fans, by R. V. Norris, Wilkes-Barre, Pa.

*Discussion of the paper of Lewis T. Wright, Metal-Losses in Copper-Slags, by J. Parke Channing, New York, N. Y.

*Discussion of the paper of Charles R. Keyes, Borax-Deposits of the United States, by A. M. Strong, Bishop, Cal.

*Discussion of the paper of E. W. Parker, The Conservation of Coal in the United States, by W. L. Saunders, New York, N. Y.

Discussion of the paper of Charles R. Keyes, Ozark Lead- and Zinc-Deposits. Mr. Keyes's reply to Mr. Buckley.

Discussion of the paper of Charles R. Keyes, Genesis of the Lake Valley, New Mexico, Silver-Deposits. Mr. Keyes's reply to Messrs. Courtis and Macdonald.

Discussion of the paper of James Douglas, Conservation of Natural Resources, by James Douglas, New York, N. Y.

Discussion of the paper of Albert F. J. Bordeaux, The Cyaniding of Silver-Ores in Mexico, by Herbert A. Megraw, San Luis de la Paz, Guanajuato, Mexico.

Discussion of the paper of H. O. Hofman and C. R. Hayward, Pan-Amalgamation: an Instructive Laboratory-Experiment, by George W. Riter, Salt Lake City, Utah.

During the sessions there was exhibited in the lecture-hall for the first time an exceedingly good portrait in oil by Farley, a Philadelphia artist, of the late Thomas M. Drown, for many years Secretary, and in 1897 President of the Institute. This portrait was presented to the Institute by James Gayley, Dr. James Douglas, and Dr. R. W. Raymond.

EXCURSIONS AND ENTERTAINMENTS.

BY JOSEPH STROTHERS.

On Wednesday afternoon, March 2, through the courtesy of the officials of the U. S. Geological Survey, a party of Institute members and guests, numbering about 100, visited the Testing Station of the Technologic Branch of the Survey at Arsenal Park. Under the supervision of Dr. Joseph A. Holmes, Chief of the Division, the party was divided into sections, and, with special guides, witnessed many interesting and instructive tests. Descriptive pamphlets were distributed so as to furnish every one with the principal details of each test.

The Gas- and Dust-Gallery.

The first test made was to determine the effect of a charge of "permissible" explosive fired into an atmosphere containing a given amount of bituminous coal-dust. The gas- and dust-gallery for the explosive tests consists of a horizontal sheet-iron cylinder, 100 ft. long and 6 ft. 4 in. in diameter, with a number of weighted cast-iron doors along the top and glass windows along one side for observing the progress of the flame.

Eight narrow sheet-iron shelves, four on each side, extend the entire length of the gallery for holding the coal-dust. A supplementary horse, 20 ft. long and 12 in. wide, placed in the section of the gallery near the cannon, is also used for this purpose. One end of the cylinder is completely closed by a massive concrete wall, in which is imbedded the heavy steel cannon containing the charge of explosive; the bore-hole of this cannon is 2.25 in. in diameter and 21.5 in. in length, and its axial line is coincident with the axis of the gallery; the other end of the cylinder is open to the air.

All permissible explosives are required to pass three series of tests. In one, a mixture of gas and air containing 8 per cent. of methane and ethane is used; in another, a mixture of gas, air, and dust, containing 4 per cent. of methane and ethane, is used; and in another, dust and air without gas are used.

Two demonstrations were made, both in an atmosphere of dust and air, to illustrate the difference between a permissible explosive and a non-permissible explosive.

In the first test, a charge of permissible explosive was tamped with 1 lb. of dry fire-clay, equivalent in disruptive force to 0.5 lb. of 40-per cent. nitro-glycerine dynamite. This was fired from the cannon into the gallery, which contained 120 lb. of bituminous coal-dust from the Pittsburg seam, 100-mesh fine, 100 lb. on the side-shelves, and 20 lb. on small horses in the sections near the cannon. In firing this charge there was a loud report, and some of the dust was expelled with the gases from the open end of the gallery. There was no ignition or charred dust, and no flame was visible through the windows.

A second test was made later in the day, using the same coal-dust, but replacing the permissible explosive by a charge of 3 F black blasting-powder tamped with 2 lb. of fire-clay, equivalent in disruptive force to the first test. This powder is not on the permissible list, and its use in the coal-mines of Pennsylvania is prohibited. On firing the charge into the gallery having the same quantity of coal-dust distributed along the shelves and on the horse, ignition took place and a heavy report followed; through the side windows the flame was seen to traverse the entire length of the gallery and rush out of the open end to a distance of 40 ft. or more, accompanied by a dense cloud of smoke, which continued to pour out for several min-

utes. The weighted doors were blown upward for an instant, and volumes of dense black smoke shot up into the air. J. R. Cavanaugh, an assistant at the Testing Station, donned one of the safety-helmets, entered the gallery, which was filled with dense and hot smoke, and traversed the entire length and back, thus demonstrating the great aid of the helmet in rescuing entombed miners.

These two tests are of especial educational value in that any mine-operator or miner can have a test made with coal-dust from his own mine with powder taken from his own magazine.

The Ballistic Pendulum.

Another demonstration made in connection with explosives attracted a great deal of interest. A test was made with the ballistic pendulum to determine the unit disruptive-charge of a given powder. The apparatus comprises a 31,600-lb. steel mortar, suspended by a heavy frame-work, the cross-bar of which rests on steel knife-edges placed at the top of heavy concrete columns, thus forming a pendulum; the radius of swing is 89.75 in. A charge of the powder to be tested—in this case 3 F black blasting-powder—was placed in a heavy nickel-steel cannon resting on a carriage, and tamped with 2 lb. of dry fire-clay. The carriage was then moved forward until the mouth of the cannon was directly against the mouth of the suspended mortar and the charge fired. The force of the explosion, being expended into the mortar, caused it to swing backward, and by a simple mechanical attachment placed beneath it at the back, the extent of the swing was recorded, 3.16 in., thus giving an empirical measurement of the amount of force exerted. By knowing the extent of the swing caused by the explosion of a given powder selected as a standard, a comparison of the strength of any other powder is thus easily obtained.

The unit disruptive-charge of an explosive is such a weight that will cause the mortar to swing the same distance as 0.5 lb. of the Pittsburgh Testing Station standard 40-per cent. nitro-glycerine dynamite.

The explosion-tests were in general charge of Clarence Hall, explosives engineer, and were demonstrated by his assistants, Spencer P. Howell and A. J. Hazlewood.

The Lamp-Gallery.

The lamp-gallery was visited and demonstrations were made, under the supervision of J. W. Paul, to illustrate the degree of safety of miners' lamps when placed in a moving current of an explosive mixture of air and gas.

The chamber in which the lamps are tested consists of a steel gallery, 6 by 12 in. in cross-section by 20 ft. long. At one end the air and gas are admitted, and caused to move at desired velocity through the gallery by means of a Koerting steam-exhauster placed at the opposite end.

The gallery is designed so as to admit of the current of air and gas impinging against the lamp, horizontally, vertically up or down, and diagonally up or down at 45°. At each observation-point is a double-plate glass door. Six explosion-relief doors are fitted to the gallery.

The first test showed the effect of an explosive mixture of air and gas, containing 8 per cent. of methane and ethane, upon a single-gauze unbonneted safety-lamp, lighted, at a velocity of current of 600 ft. per min. An explosion occurred in 11 seconds.

The lamp used in this test was a type of the original Davy, which is condemned for use in the coal-mines of several countries, although used largely in some of the mines in the United States by fire-bosses.

The second test was with the same explosive mixture, but at a velocity of 2,500 ft. per min.; a lighted double-gauze bonneted safety-lamp was used. There was no explosion, although the test lasted for 1.5 min. The wick relighted on removal from the gallery.

This lamp is of a type largely used in Germany and Belgium, and of late years has been introduced into the mines of the United States. It is considered to be one of the most approved types.

The demonstration-room devoted to mine-rescue apparatus came in for a full share of praise, but before viewing the apparatus a lecture was given by J. W. Paul, explaining the various appliances exhibited at the station. At one side of the training-room is a collection of many kinds of helmets and other devices to permit the wearers to work in an atmosphere of irrespirable gases. At the other side is an air-tight glass

partition closing off a wide space, which is fitted up with tracks, trucks, heaps of rock and coal, timbers, small passageways, etc., all arranged to reproduce the physical conditions which may be encountered in an ordinary mine. This special compartment is devoted to the instruction of assistants in the use of rescue-apparatus while enveloped in choking and poisonous gases.

The Combustion-Furnace.

The chemists and metallurgists of the party were particularly interested in the long combustion-chamber furnace, installed in a separate building, and used to determine the combustion-qualities of a given fuel. The fire-place at one end is operated in the ordinary manner, control being had of the amount of air supplied to the fuel burning in the grate. The gases of combustion pass through the long chamber to the chimney at the other end of the furnace. Special water-cooled attachments permit the simultaneous taking of nine samples, one from any part of each square foot of the cross-section of the chamber. At the same time, thermo-electric pyrometers give the temperature of each sample as it is taken from the furnace. In the wall at the end of the furnace, below the chimney, but above the level of the hearth, is a small blue-glass peep-hole, which gives a full view of the interior of the combustion-chamber and permits continuous observation of the swirling currents of burning gases as they pass through the furnace.

A complete account of this apparatus, and of the purpose of the experiments in progress with it, will be published as a separate paper in a later number of the *Bulletin*.

The Electrical Laboratory.

The party, divided in small sections, witnessed a number of interesting tests in the electrical laboratory, to show the effect of electric sparks of various strengths on an explosive mixture of natural gas and air, similar to the mixture used in the tests with the safety-lamps. These tests were made by H. H. Clark and his assistant, William Buhl, Jr.

The spark-tests were made in a sheet-iron box, provided with a door in which a paper diaphragm can be inserted to relieve the force of the explosion. The box is provided with inlets

for Pittsburg natural gas and compressed air, and also has connected to it the intake and discharge of a small, motor-driven circulating-fan to insure a thorough mixture. The gas is admitted through a gasometer in pre-determined quantities and then mixed for a definite time by the circulating-fan. By previous calibration any percentage of natural gas and air can be accurately obtained in this manner. After an explosion has taken place in the box, the products of combustion are removed by blowing compressed air through the box before the gas is again admitted.

The first test was the opening, in a gaseous atmosphere, of a 500-volt direct-current circuit containing a small amount of inductance. The mixture of gas and air was combined in the most explosive proportions. The circuit was opened at various current-values, increasing the current until the explosion occurred. The average current at which an explosion occurred was 0.18 ampere. These results show that at 500 volts an explosive spark is produced by a very small amount of current (a strength of 0.18 ampere is about one-third of the current taken by an ordinary 110-volt, 16 c-p., carbon-filament incandescent lamp).

The next experiment was opening a 25-volt, direct-current, non-inductive circuit in a mixture of gas and air, combined in the most explosive proportions. The circuit was opened at various currents, beginning at low values and increasing the strength of the current until an explosion occurred. The average value of the current which gave an explosion was 3.5 amperes. This test shows that it is possible to break a very considerable amount of current at 25 volts without obtaining an explosive spark, provided that the circuit is non-inductive; 25 volts is about the potential which would be obtained by connecting 16 dry batteries or 12 storage-batteries in series, and is therefore much greater than the voltage of most, if not all, portable electric lamps. On the other hand, 25 volts would be a reasonable potential for signal-systems operated by batteries.

The next experiment was the breaking of a 25-volt, direct-current, inductive circuit in a mixture of gas and air combined in the most explosive proportions. The circuit was opened at various strengths of current, beginning at very low values and increasing the current until an explosion occurred. The aver-

age current at which an explosion occurred under these conditions was 0.45 ampere. This result shows that by introducing inductance into the circuit, an explosive spark is obtained at a much lower current-value. An electro-magnet of any sort represents inductance, and a circuit made up of such magnets or similar equipment would be highly inductive.

The next experiment was the breaking of a 220-volt, 8-c-p., carbon-filament, incandescent lamp in a mixture of gas and air combined in the most explosive proportions. The breaking of this lamp did not explode the surrounding gaseous mixtures.

The final experiment was the breaking of a 55-volt, 32-c-p., carbon-filament, incandescent lamp in a mixture of gas and air combined in the most explosive proportions. The breaking of this lamp immediately caused a very violent explosion of the gas surrounding the bulb.

The experiments with the lamps show that the likelihood of explosion of gas surrounding an incandescent lamp, when the bulb is smashed, depends upon the size and mass of the incandescent lamp-filament. Although both filaments are broken almost instantaneously when the bulb of the lamp is smashed, the 220-volt, 8-c-p. filament is so very small that the inrush of the gaseous mixture immediately chills it below the temperature of ignition of the gas, while in the case of the 55-volt, 32-c-p. lamp having a large filament, the cooling-effect of the gas did not reduce its temperature below the ignition-point of the gas, and an explosion resulted.

The Briquetting-Plant.

The demonstration with the briquetting-press was conducted by Charles L. Wright, Chemical Engineer, in charge of Briquetting Section, using the German lignite-briquetting equipment of the Survey. The material used was California lignite, dried to contain from 10 to 15 per cent. of moisture, and agglomerated by a pressure of 20,000 lb. per sq. in. without the addition of any binding material. The briquettes produced were elliptical in the largest cross-section and rectangular in any other section. The capacity of the plant is from 2.5 to 3 tons per hour, depending upon the material used. The raw material was prepared as follows:

After crushing in a roll-crusher to 0.25-in. size or smaller, the lignite is fed to a Schulz drier heated by the exhaust steam from the briquette-press engine. From the drier the material enters a sorting-sieve, and any oversized pieces are crushed between a pair of smooth-faced rolls. The dried material is then cooled in a cooling-apparatus and elevated to a large hopper over the press. From this hopper the prepared material is fed to the press automatically and compressed into briquettes, which are hard and firm, and suffer but little in transportation. There is no deterioration in storage. The press is of the open-mold class, and exerts pressures ranging from 14,000 to 28,000 lb. per sq. in. This press is adapted for briquetting lignite and peat, and with lignites only those containing more than 2 per cent. of matter soluble in carbon disulphide can be satisfactorily treated.

The lignite-briquetting tests made by the Survey during the years 1909 and 1910 have determined that some of the American lignites can be made into satisfactory briquettes with this machine.

The Mechanical-Testing Laboratory.

A tension-test was made of a cable on the 600,000-lb. Olsen machine, in charge of Harry Kaplan, Assistant Engineer.

The piece of cable tested was cut from a coil intended for use on unloaders at the Isthmus of Panama. The sample was 6 ft. long, and consisted of six strands of 19 wires each and a special core, also of six strands of 19 wires each, all of hard steel, with a hemp center, the total sectional area of all wires being 1.064 sq. inches.

Cables are tested according to specifications, involving sometimes tests on individual wires, as tension, torsion and bending, chemical tests, etc. In the present case, only the ultimate strength over full cable section was required. To grip the cable in the testing-machine, each end of it was "bushed" for 6 in. and the wires wiped clean. To keep the cable from unwinding, strong wire was wrapped around it 6 in. from either end for about 3 in.; the cable was then set up carefully in a vertical position with one bushed end in a steel tapered block, 9.5 in. long on top and 8 in. on bottom, 5 in. thick and 5 in. deep, having a conical hole in it of a diameter of 3.75 in. at top and $1\frac{1}{2}$ in. at the bottom. In this hole molten zinc is

poured, thus gripping the ends of the wires in the block, which will fit snugly in the hole of either head of the testing-machine. The lower end of the cable was similarly treated, except that its block was narrower in order to allow it to pass the hole in the upper head of the machine and be gripped in the lower head by means of liners.

The testing-machine is a 600,000-lb. Universal, vertical, four-screw machine, electrically operated. The four screws, 4 in. in diameter, do not turn, but are moved up and down simultaneously by four different gears at the bottom. The screws engage in the lower head, exerting the necessary pull. The head can also be moved on the screws by means of differential gears on the head. The stationary head is the upper one, and can be secured to the frame of the machine in six different positions by keys or bars running through slots in the head and frame. The upper head is moved from one position to another by bringing the lower or pulling head under the upper head, removing the keys, running down both heads to the proper position, and placing the keys in the corresponding slots.

Compression- and transverse-pieces are placed between the lower head and bed of machine, and tension-pieces between the two heads, hence the screws are always in tension. The pressure exerted is transmitted by a system of levers to the weighing-beam, having a dial-vernier and three poises for 600,000, 300,000, and 30,000 lb., giving an accuracy of 0.3 per cent.

The cable was gripped carefully between the two heads, and an initial load of 2,000 lb. applied to insure the central position of the cable in the machine. Increments of 10,000 lb. were then gradually applied, and readings were taken at each application for the average decrease of diameter of rope by a micrometer caliper, and for its elongation between two points, 2.5 ft. apart, by a rule. Readings were not taken after the load reached 200,000 lb., at which the "first sound of failure" was heard, that of several individual wires parting. At 200,000 lb. the average reduction in diameter was 3.1 per cent. and the elongation, 3.5 per cent. At the ultimate load of the cable of 210,380 lb., giving a corresponding unit-stress of 197,700 lb. per sq. in., two strands and all of the special core parted at the middle of cable.

A compression-test on concrete was made on the 200,000-lb. machine, in charge of Elvin R. Gates, Junior Engineer.

One of the important variables of concrete is age, therefore test-pieces of concrete are studied at regular periods in order to determine the increase in the strength with age. The test-pieces were 8- by 16-in. cylinders, and three cubes, 6-in. on edge, of concrete, being a part of a series of tests on gravel used at the Isthmian Canal for reinforced concrete piles. This part of the series consists of three sets of cylinders and a large number of sets of cubes. The three sets of cylinders were made of pit-run gravel, in the proportion of 1:0:6. All cylinders after molding were regularly cured in the damp closet for four weeks, and the first set was left in the damp closet; a second set was placed in fresh water, which is renewed every other day, and a third set was sent to the Atlantic City Laboratory of the Structural Materials Division, where they were placed in sea-water, which is also renewed every other day. Each set numbers 12 cylinders, 3 of each set being tested at intervals of 8, 13, 26, and 52 weeks.

The sets of cubes were made of different proportions and of different sizes of the gravel, in order to determine the densest and strongest mix that can be obtained from the gravel.

There are also many cylinders of different proportions of mixture having a light metal imbedded in them in various ways, so as to represent the ordinary construction of concrete-piles. These cylinders are immersed in the sea-water after having been cured in the damp closet for four weeks. At regular periods, ranging from eight weeks to two years, these cylinders will be broken open and the condition of the imbedded metal noted as regards corrosion. There are also a large number of absorption-test pieces and other chemical and physical tests connected with this investigation.

The six cylinders tested were eight weeks old, of a proportion of 1 : 0 : 6 pit-run ; three were cured in the damp closet and three in fresh water, and these cylinders were tested on a 200,000-lb. testing-machine similar to the 600,000-lb Olsen machine. A short time before testing the ends of the concrete test-pieces in the testing-machine were smoothed off with plaster of paris at right angles to the axes in order to insure an even distribution of load over the area. For this purpose a rigid table is used, the top of which is horizontal, and consists of a heavy piece of plate-

glass about 1 ft. square. The glass is first oiled, then plaster of paris mixed with water is spread on it about 0.25 in. thick, into which the test-piece is forced before the plaster of paris sets in such a manner that a layer about $\frac{1}{8}$ or $\frac{1}{4}$ in. thick is left on the test-piece. The sides of the test-piece are maintained vertically by means of a spirit-level. After the plaster of paris is set, the other end is similarly treated.

On the cylinders a brass compressometer is used to measure the vertical deformation under load. It consists of two yokes placed exactly 12 in. apart equal to the gauge-length. From the top yoke two rods project and come in contact with micrometers, reading to 0.0001 in., on the lower yoke on either side of the test-piece. Contact is obtained by listening for the making and breaking of an electric circuit in a telephone receiver. By plotting the unit reading, the initial modulus of elasticity is obtained.

The load is applied continuously at a speed of about $\frac{1}{40}$ in. per min., readings being taken at each increment of 5,000 lb., or about 100 lb. per sq. in. The load at the first crack, the maximum load, and the appearance of the ruptured cylinders are recorded.

A tension-test on steel was made under the charge of E. B. Tolstead, Assistant Engineer. A piece of steel rod, 1 in. in diameter and 18 in. long, was tested on the 100,000-lb. Universal testing-machine, similar in construction to those already described. The steel was cut from a rod that was used in a test-piece of reinforced concrete for determining the bond between the concrete and the steel. A Henning extensometer with electric contact was used, and the elongation measured over a gauge-length of 8 in. The modulus of elasticity was determined by plotting unit-stresses and unit-elongations and drawing a tangent to the curve below the elastic limit. The results obtained in this test correspond with those for mild steel—namely, elastic limit, 36,000; yield-point, 38,000; maximum unit-stress, 84,700 lb. per sq. in.; the modulus of elasticity was 32,000,000.

Clay-Testing Department.

The tests and investigations of clay products were under general charge of Dr. Albert V. Bleining, Ceramic Chemist.

In the machinery-room the grinding- and molding-machines

used in the testing of clays were shown in operation by G. H. Brown, assisted by R. K. Hursh. At the time of the visit, samples of clay from Texas were being put through the machines, a work undertaken in co-operation with the Geologic Branch of the Survey. The facilities for drying were also shown, with special reference to the preheating carried on in connection with the use of certain excessively plastic clays from Western States, which so far have been found unworkable, but which are important deposits from the fact that the localities from which they were obtained lack other structural materials, such as timber and stone.

W. E. Emley explained the work being done on the examination of limestone and limes, which it is hoped will bring out important information for the benefit of the consumer and the manufacturer.

In the adjoining kiln-house a fire-brick test was in progress, and the operation of the furnace was explained by A. V. Bleining, in charge of the Clay Products Section. In this particular test the behavior of fire-bricks under a compression-load of 50 lb. per sq. in. at a temperature of $1,350^{\circ}$ C. was being studied. Some interesting results have been brought out in this connection, and it has been possible to discriminate sharply between materials suitable for withstanding load-conditions at common furnace-temperatures and those which are not suited for such use. This refers particularly to gas-benches, blast-stoves, muffles, retorts, crowns, etc.

At the same time the two down-draft kilns used for burning the specimens were shown in operation. In each of these test-kilns more than a ton of clay-ware may be burnt under conditions closely approximating the conditions of practice. By means of pyrometers, draft-gauges and gas-analysis apparatus, the rate of heating and cooling and the effect of oxidizing and reducing conditions may be followed.

In a small electrical carbon-resistance furnace higher temperatures for fusion-tests of refractory materials may be reached.

In another building a demonstration of slimes was made by Harrison E. Ashley, which consisted in an exhibition of the apparatus used in his study of the conditions under which clays and slimes are dissolved or suspended in water, and are coagulated or precipitated therefrom.

Two elutriation apparatus (similar to conical classifiers) were in operation, their products were exhibited, and a wall-chart showed that the temperature of the water-supply, within the range of ordinary atmospheric temperatures, has a profound influence upon the size of the products.

In tubes it was shown how the best proportion of reagent can be determined, either for cleaning the colloidal matter entirely from the crystal grains, or for coagulating slimes. The results of such determinations were shown in wall-charts. According to these results, an excess of lime beyond the minimum requirement for classification is disadvantageous. In certain cases, other inexpensive salts give a better action than lime.

On Thursday morning, March 3, through the courtesy of J. D. Callery, President of the Pittsburg Railways Co., special trolley-cars were provided to convey about a hundred members and guests of the Institute to the steel plant of the Carnegie Steel Co., at Homestead, where exceptional facilities were provided for the instruction and entertainment of the party. The special committee to receive the party and conduct it through the plant consisted of:

Col. A. R. Hunt, *General Superintendent*; J. H. Grosse; J. C. Lawler; L. R. Custer; L. M. Hartzell; W. H. Packer; James Horton; L. P. Lincoln; R. H. Watson; A. A. Corey, Jr.; Charles Orchard; and S. S. Wales.

It was manifestly impracticable to inspect the entire plant, the grounds of which, on the river-front alone, extend over a distance of 2.5 miles; moreover, it is beyond the province of the present description to recite in detail all that was seen. At first the party went through one of the basic open-hearth departments, and the various details of operation were viewed with interest and interrogation. In all, there are 66 furnaces, of individual capacities up to 75 tons, and two stands of acid Bessemer converters. The plate-mill was then visited, and the 40-in. universal mill, erected more than 20 years ago by S. T. Wellman, who was in the party, came in for a good share of admiration and comment. Soaking-pits, reheating-furnaces, 120-in. finishing-rolls, cooling-tables, shears, straight and circular, were viewed and discussed, but of particular and fascinating interest was the Wellman electric charger, which served eight furnaces, four on a side, picking up cool slabs from the

transfer-rolls, charging them into one furnace, then moving rapidly to another furnace, reaching in, picking up other hot slabs, and carrying them to the transfer-apparatus which supplies the finishing-mill—all done quickly, gracefully, and apparently with almost human intelligence. For the further entertainment of the party, the operator made the immense charger “do stunts,” swinging around in one direction, then reversing, then up, down, forward, and back. It really seemed as if the machine were actually waltzing around, around, and around. One enthusiastic observer remarked: “My! what a machine! Performing all its manifold functions without once sitting down to rest!”

The Harveyizing branch of the armor-plate department called forth exclamations of praise. The enormous hydraulic presses which reduce the ingots of 50 tons weight, or more, into plates, the old Harveyizing furnace, and the cooling-sprays for hardening the plate after the surface had absorbed the desired amount of carbon, came in for a share of comment and inquiry. Partly-finished plates up to a thickness of 14 in., or more, were examined, and the manner of obtaining the test-pieces, as required by the government, was explained in detail. Fractures showing the change in structure from the hardened surface to the tough interior were studied with interest, and many questions were propounded as to the relative merits of chromium, nickel, vanadium, tungsten, molybdenum, alone and in combination, without being too definitely answered by the cautious experts in charge of the work.

After the operations of the armor-plate department had been inspected, as well as the short time permitted, the party boarded a special train and was conveyed across the “hot metal” bridge to the Carrie furnaces on the opposite bank of the river, 2.5 miles distant. The metal tapped from the blast-furnaces into ladle-cars is carried over this bridge to the open-hearth furnaces while still molten. The flooring and side-walls of the bridge are lined with fire-brick, in order to prevent any damage to boats passing under it by metal spilled in a possible derailment or the breaking of a ladle. A hasty trip was made through the blast-engine house and around the blast-furnaces and hot-blast stoves. The train was again boarded, and the party, now hot and foot-weary, hailed with joy the statement

that the next department to be visited was the "Commissary." In the Firemen's Hall at Munhall a delightful and refreshing luncheon was served by the courtesy of the Carnegie Steel Co. Col. A. R. Hunt presided, and brief speeches of welcome by our hosts on the one hand, and hearty thanks by President Brunton and Vice-President Saunders, on the other, followed in rapid succession. The remainder of the afternoon was devoted to a special trip by a selected few to the electric steel, open-hearth, refining furnace of the Carnegie Steel Co., and to the admirable plant of the Mesta Machine Co., an abridged description of which, taken from the *Iron Age*, Aug. 16, 1909, follows:

The large plant of this company is situated in West Homestead, Allegheny county, Pa., on the Monongahela river, about 6 miles from the business center of Pittsburgh, and adjoining Homestead, Pa. Much of its product—heavy-duty engines for rolling-mills, blast-furnaces and power-plants, rolling-mill machinery, chilled rolls, steel castings, and machine-molded gears—has to be shipped but short distances. But the plant has also direct connections with the Pennsylvania, Baltimore & Ohio, Pittsburgh & Lake Erie and New York Central railroads. By way of the Monongahela river, it receives much of its raw materials and supplies, and ships some of its products. The floor-level is 15 ft. above the highest level reached by the river.

The plant covers about 20 acres, has about 500,000 sq. ft. of floor-space under roof, and over 400,000 sq. ft. covered by electric traveling-cranes. Behind the four-story, fire-proof office-building are the fire-proof machine- and erecting-shops, built of steel, concrete and fire-brick, with a combined width of 210 ft. and a length of 1,000 ft. The overhead traveling-cranes in these departments, and the machine-shop tools, are capable of handling the heaviest pieces of machinery that can be shipped.

Adjoining the lower end of the machine- and erecting-shops is the power-plant. An overhead bridge from the boiler-house to the river conveys coal from barges to the storage, or shipments of machinery by river. On the river-side of the machine-shop is a yard covered by two electric traveling-cranes, running the entire length of the shop. This yard is used for storing castings as they come from the foundry until the machine-shop is ready to receive them. Directly back of the power-house is a large forge-shop, and immediately behind this the foundry, paralleled by a two-story and basement pattern-shop, 60 ft. wide and 175 ft. long, and pattern-storage buildings. The foundry building has a main bay 80 ft. wide, a side bay 60 ft. wide and a 25-ft. lean-to on the opposite side. This foundry is also equipped with overhead traveling-cranes and traveling jib-cranes.

On the river-side of the foundry building is an 84-ft. yard covered by 30-ton traveling gantry-cranes. This yard is used for storing raw materials, flasks, etc., and through it car-loads of material are distributed to the various departments by the locomotive of the company.

The Office Buildings.

The office building has four floors. The first contains the time-office; an emergency-hospital; a library for the employees, where all the leading technical and

scientific periodicals are provided; and a private dining-room for visitors and officers of the company, as well as a larger dining-room where luncheon is served daily to the office-men, foremen and assistant foremen of the works. On the second floor are the business offices. The third floor is devoted to the sales department, comprising the offices of the vice-president and sales-manager, the estimating department, blue-print room, photographic department, letter-files, offices of the selling engineers, a reception-room for visitors, and a fire-proof vault where all foreign tracings, blue-prints and drawings are kept. The fourth floor is occupied by the engineering department with drafting-rooms and offices, and fire-proof vaults for designs and tracings.

The Machine- and Erecting-Shops.

Like the walls, the floors of the machine-shop are of concrete, except certain sections, which are heavy cast-iron plates slotted for bolting heavy castings solidly to the floor, enabling simultaneous operations with portable tools to be performed on a single piece of machinery. Frequently as many as three or four tools are operating on a casting at the same time.

One of the erecting departments, 60 by 100 ft. in size, has a floor consisting of a concrete slab 4 ft. thick. Here the vertical engines, such as blowing-engines and mill- and power-machines, are erected. This special heavy floor was installed so that engines 50 ft. high could be erected without danger of settling out of alignment during the process. This erecting floor has two craneways, respectively 35 ft. and 50 ft. above the floor. Four pairs of vertical cross-compound blowing-engines 48 ft. high have been erected on this floor at the same time.

The Roll-Shop.

The large and well-lighted roll-shop is equipped throughout with special heavy roll-lathes of the company's own design and construction. Any class of roll- or pinion-work can be executed expeditiously. Many shapes and sizes of sand-cast, chilled and steel rolls, for rolling iron, steel, brass, copper, zinc, rubber, glass, and paper, are here manufactured, as well as special water-chilled rolls and the Mesta patented vanadium-steel roll, which is used for purposes requiring a close tough metal.

The Forge-Shop.

This shop contains three heavy hammers, four forges, and a large gas heating-furnace. It is always well stocked with ingots from the open-hearth steel-melting department, comprising carbon-steel of any desired percentage of carbon, nickel-steel, and vanadium-steel. Particularly with regard to the latter alloy, this company has an advantage in making its forgings at the same plant where the original ingot was poured, enabling it to make prompt deliveries, and to keep complete record of its chemical analysis and physical tests of every heat.

The Gear-Department.

One of this company's specialties is the manufacture of gears. Fifteen years ago, having decided that the old method of making gears from wooden patterns was not sufficiently accurate to meet the demands of modern machinery, it started to develop gear-molding machines. These machines have been perfected and patented, and are now used by this company for making all cast gears.

The gear-cutting department is equipped for cutting spur-gears of all sizes up to 20 ft. in diameter, and bevel-gears up to 16 ft. in diameter. For all large spur and bevel gear-cutting, gear-planers are used. In making large cut gears, the molds

for the castings are first made on the gear-molding machines, leaving sufficient excess material on the teeth so that they can afterwards be planed.

The Pattern-Shop.

The pattern-shop has been built as nearly fire-proof as possible. The heavy steel frame is imbedded in concrete, and the roof is of reinforced concrete.

On the top floor, patterns for large engines, bed-plates, and the like, are made. In addition to the windows, a large skylight extends the length of the building. It is very important in making large patterns to have overhead-light in addition to the side-light.

In one section of the first floor, tooth-blocks for the gear-molding department are made. This floor is also well lighted by windows on all sides, and is equipped with modern wood-working tools. The offices of the foreman and the clerical forces are inclosed by concrete partitions, thus assuring safety of records, prints, and designs from fire.

The Pattern Storage.

The top floor of the pattern-storage building consists of a number of rooms forming 60-ft. sections divided by fire-proof walls, with fire-proof doors of heavy steel. In these rooms all patterns are compactly stored in such a way that any desired pattern can be instantly found and sent to the foundry across the bridges which connect the two buildings.

The Iron-Foundry.

This building attracts attention by its great height and massive strength. The columns are spaced 20 ft. apart, forming 20-ft. bays; and the span of the main foundry is 80 ft., over which travel 100-ton electric cranes. Along the side are numerous jib-cranes, used for the lighter work, such as setting cores, handling flasks and supplies.

In the side foundry, which is 60 ft. wide, where the smaller work is made, the equipment is about the same as in the larger part, the only difference being that the capacity is limited to 50 tons. The roof of the foundry is of reinforced concrete, 4 in. thick, and simply finished with a surface coat. It has been found after a year of service to be thoroughly water-proof and not to require the application of any other material on the surface.

The Core-Ovens.

The core-ovens represent a new idea in construction, the furnaces and store-room for the cores being entirely underground. The furnaces are fired with coke, and the upper parts of the ovens are covered by rolling doors of steel.

The Air-Furnaces and Cupola.

The air-furnaces have a capacity for melting 250 tons of iron, if necessary, in one heat. For the smaller castings, and for feeding the larger ones, the iron is melted in an 84-in. cupola. The size of castings made in this foundry is limited only by the carrying-capacity of the railroads.

The Brass-Foundry.

The brass-foundry is equipped with a converter and crucible pots, and an electric hoist furnishes the power for handling the work.

The Steel-Foundry.

The steel-foundry is equipped with acid open-hearth furnaces with a capacity of 125 tons of steel castings a day. Single castings can be made in steel up to 100,000 lb.

The Roll-Foundry.

This company has long been eminent in the manufacture of rolls; but probably few are aware of its constant efforts to find better ways of casting chill-rolls. The greatest success has come with the use of vanadium-steel, and of the special water-chilling process, by which any degree of hardness or any depth of chill desired in a roll can be attained. This chilling, being done mechanically, permits the use of a tougher and stronger iron than was formerly possible, since the chilling then depended solely on the chemical composition of the iron, and consequently the rolls were brittle.

Notable Products of the Company.

The plant of the Mesta Machine Co. was designed and built especially for the building of heavy-duty engines for blast-furnaces, rolling-mills, and power-plants, and also of machinery used in the manufacture of iron and steel. Some of its noteworthy installations are as follows: Five horizontal cross-compound blowing-engines for the two 600-ton blast-furnaces of the Illinois Steel Co.; five vertical cross-compound blowing-engines for the two 600-ton blast-furnaces of the Donora plant of the Carnegie Steel Co.; twenty-four blowing-engines for the Tennessee Coal, Iron & Railroad Co. (said to be the largest group of engines of one make in any plant in the United States); five blowing-engines for the Cleveland Furnace Co.; two pairs of 55- by 66-in. piston-valve reversing-engines for the Tennessee Coal, Iron & Railroad Co. for driving its blooming- and rail-mills; one pair of 50- by 60-in. reversing-engines for the Illinois Steel Co.; three reversing-engines for the National Tube Co.; two pairs of twin tandem-compound reversing-engines for the Bethlehem Steel Co.; one 44- and 76-in. by 60-in. cross-compound engine for the Bethlehem Steel Co. (the total weight of this engine was over 1,000,000 lb. and some of its individual castings weighed over 100 tons); one large tandem-compound engine to drive the rail-mill of the Inland Steel Co.; one horizontal vertical engine to drive the rail-mill of the Tennessee Coal, Iron & Railroad Co.; and one Corliss engine which drives the billet-mill of the Clairton Works of the Carnegie Steel Co.

The facilities for building engines were strikingly illustrated a few months ago when a 36- by 72-in. heavy-duty Corliss engine, with 100-ton fly-wheel, was completed ready for shipment in 30 days from the receipt of the order.

In addition to the excursions above described, invitations were extended to the Institute party to inspect the plants of the following companies: Westinghouse Electric & Manufacturing Co.; Jones & Laughlin Steel Co.; C. G. Hussey & Co.; H. K. Porter Co.; Pennsylvania Drop Forging Co.; Zug Iron & Steel Co.; American Bridge Co.; Pittsburg Steel Co.; Park Steel Works, Crucible Steel Co. of America; Pressed Steel Car Co.

Special Excursions for the Ladies.

On Wednesday, March 2, the ladies of the Institute party were entertained at a luncheon given at the Allegheny Country Club, several miles from Pittsburg. A special meeting of resident ladies received the guests, and served a luncheon, which, with the beautiful weather and the delightful surroundings, made the occasion one long to be remembered with pleasure.

On Thursday, while the members were visiting the Carnegie Steel Works and the plant of the Mesta Machine Co., the ladies enjoyed, under the guidance of Mrs. Taylor Alderdice, and others of the Ladies' Local Committee, a delightful automobile trip through the parks and residential sections of Pittsburg, visiting afterwards the famous pickle factory of H. J. Heinz Co., where luncheon was served through the courtesy of the officers of the company. Special praise was bestowed on the admirable management of the culinary department and the thorough organization of the business.

On Thursday evening a reception, dance, and collation were given in the ball-room of the Hotel Schenley, under the auspices of the Local Committee and the Ladies' Committee.

Other pleasing and instructive excursions were made by the ladies, notably to the art-galleries and museum of Carnegie Institute, the Margaret Morrison Carnegie School (which is the woman's department of the Carnegie technical school), and various places of interest in the city and environments.

Members and Guests in Attendance at the Sessions and Excursions.

Acker, Louis K., Jr., Pittsburg, Pa.	Cavanaugh, J. R., Pittsburg, Pa.
Alderdice, Taylor, Pittsburg, Pa.	Childs, Mrs. A. P., Jr., Pittsburg, Pa.
Alderdice, Mrs. Taylor, Pittsburg, Pa.	Clark, H. H., Pittsburg, Pa.
Ashley, Harrison E., Pittsburg, Pa.	Clemson, Mrs. D. M., Pittsburg, Pa.
Austin, W. W., St. Louis, Mo.	Cole, W. R., Philadelphia, Pa.
Bassett, Mrs. G. P., Pittsburg, Pa.	Collord, George L., Sharpsville, Pa.
Beik, Emile, New York, N. Y.	Conrad, H. V., Pittsburg, Pa.
Bell, Robert, Ottawa, Can.	Conrad, Mrs. H. V., Pittsburg, Pa.
Bell, Miss, Ottawa, Can.	Corey, A. A., Pittsburg, Pa.
Bellinger, H. P., Syracuse, N. Y.	Crabtree, Fred, Pittsburg, Pa.
Bellinger, Mrs. H. P., Syracuse, N. Y.	Craver, Harrison, W., Pittsburg, Pa.
Beyl, Z. S., Buenos Aires, Argentine Republic, S. A.	Crawford, R. C., Pittsburg, Pa.
Bibbins, J. R., Pittsburg, Pa.	Crawford, Mrs. R. C., Pittsburg, Pa.
Birkinbine, J. L. W., Philadelphia, Pa.	Cooper, Mrs. S. G., Pittsburg, Pa.
Birkinbine, John, Philadelphia, Pa.	Custer, L. R., Pittsburg, Pa.
Blauvelt, W. H., Syracuse, N. Y.	Davidson, G. M., Chicago, Ill.
Bleininger, Dr. A. V., Pittsburg, Pa.	Day, David T., Washington, D. C.
Bope, Col. H. P., Pittsburg, Pa.	De Wolf, F. W., Urbana, Ill.
Bostwick, W. A., Pittsburg, Pa.	Dinkey, A. C., Pittsburg, Pa.
Bostwick Mrs. A. A., Pittsburg, Pa.	Dinkey, Mrs. A. C., Pittsburg, Pa.
Brashear, Dr. John A., Pittsburg, Pa.	Dravo, Mrs. F. R., Pittsburg, Pa.
Brown, G. H., Pittsburg, Pa.	Dwight, A. S., New York, N. Y.
Brunton, D. W., Denver, Colo.	Dwight, Mrs. A. S., New York, N. Y.
Buhl, William, Jr., Pittsburg, Pa.	Dwight, Theodore, New York, N. Y.
Burchard, E. F., Washington, D. C.	Elmer, Wm., Pittsburg, Pa.
Callbreath, J. F., Jr., Denver, Colo.	Emley, W. E., Pittsburg, Pa.
	Fairbairn, C. T., Pittsburg, Pa.

- Gates, Elvin R., Pittsburg, Pa.
 Gluck, George, Pittsburg, Pa.
 Godley, George McM., New York, N. Y.
 Goodale, S. L., Pittsburg, Pa.
 Griffin, Mrs. Herman, Pittsburg, Pa.
 Grose, J. H., Pittsburg, Pa.
 Haldeman, George T., Pittsburg, Pa.
 Hall, Clarence, Pittsburg, Pa.
 Hansell, N. V., New York, N. Y.
 Hart, R. B., Pittsburg, Pa.
 Hartzell, L. M., Pittsburg, Pa.
 Hazlewood, A. J., Pittsburg, Pa.
 Henderson, W. M., Pittsburg, Pa.
 Herr, Mrs. B. M., Pittsburg, Pa.
 Hibbard, Henry D., Plainfield, N. J.
 Holmes, J. A., Washington, D. C.
 Horton, James, Pittsburg, Pa.
 Howell, Spencer F., Pittsburg, Pa.
 Huntoon, L. D., New Haven, Conn.
 Hursh, R. K., Pittsburg, Pa.
 Jones, J. H., Pittsburg, Pa.
 Jones, W. L., Pittsburg, Pa.
 Kann, W. L., Pittsburg, Pa.
 Kaplan, Harry, Pittsburg, Pa.
 Kennedy, Julian, Pittsburg, Pa.
 Kennedy, Mrs. Julian, Pittsburg, Pa.
 Kirchhoff, C., New York, N. Y.
 Lawler, J. C., Pittsburg, Pa.
 Le Boutillier, Clem., High Bridge, N. J.
 Lee, J. Henry, Baltimore, Md.
 Lee, Mrs. J. Henry, Baltimore, Md.
 Le Fevre, S., Mineville, N. Y.
 Lincoln, L. P., Pittsburg, Pa.
 Linville, C. P., State College, Pa.
 Lloyd, Mrs. F. H., Pittsburg, Pa.
 Lyon, D. A., Heroult, Cal.
 McCormick, R. T., Pittsburg, Pa.
 McNaughter, D. W., Pittsburg, Pa.
 MacClure, C. A., Baltimore, Md.
 MacClure, Mrs. C. A., Baltimore, Md.
 Malcolmson, C. T., Chicago, Ill.
 Marsh, Mrs. J. W., Pittsburg, Pa.
 Maynard, George W., New York, N. Y.
 Means, E. C., Low Moor, Va.
 Means, Mrs. E. C., Low Moor, Va.
 Meller, H. B., Pittsburg, Pa.
 Mellon, Mrs. T. A., Pittsburg, Pa.
 Messler, E. L., Pittsburg, Pa.
 Mesta, George, Pittsburg, Pa.
 Miller, Charles L., Pittsburg, Pa.
 Miller, Mrs. Charles L., Pittsburg, Pa.
 Nimick, Mrs. W. H., Pittsburg, Pa.
 Ohl, Mrs. E. N., Pittsburg, Pa.
 Orchard, Chas., Pittsburg, Pa.
 Ormrod, George, Allentown, Pa.
 Ormrod, John D., Allentown, Pa.
 Orton, Bror, Stockholm, Sweden.
 Packer, W. H., Pittsburg, Pa.
 Pargny, E. W., Pittsburg, Pa.
 Parker, E. W., Pittsburg, Pa.
 Pauly, Karl A., Schenectady, N. Y.
 Phillips, Francis C., Pittsburg, Pa.
 Porterfield H. A., Pittsburg, Pa.
 Raymond, R. W., Brooklyn, N. Y.
 Rea, W. H., Pittsburg, Pa.
 Rice, George S., Pittsburg, Pa.
 Richards, Robert H., Boston, Mass.
 Riley, G. H., Pittsburg, Pa.
 Rogers, John V., Jr., Philadelphia, Pa.
 Rösler, Dr., New York, N. Y.
 Ross, H. Earle, Pittsburg, Pa.
 Saunders, W. L., New York, N. Y.
 Seafife, W. L., Pittsburg, Pa.
 Schellenberg, F. Z., Pittsburg, Pa.
 Sherrerd, John M., High Bridge, N. J.
 Shriver, Mrs. V. L. P., Pittsburg, Pa.
 Smith, Franklin W., Bisbee, Ariz.
 Smith, Lloyd B., Pittsburg, Pa.
 Smith, Oberlin, Bridgeton, N. J.
 Smith, Mrs. Oberlin, Bridgeton, N. J.
 Snelling, Walter O., Washington, D. C.
 Speller, F. N., Pittsburg, Pa.
 Spillsbury, Miss B. G., New York, N. Y.
 Spillsbury, Miss R. F., New York, N. Y.
 Stanton, F. McM., New York, N. Y.
 Stoek, H. H., Urbana, Ill.
 Street, G. B., Wilmington, Del.
 Stoughton, Bradley, New York, N. Y.
 Struthers, Joseph, New York, N. Y.
 Taylor, Knox, High Bridge, N. J.
 Taylor, S. A., Pittsburg, Pa.
 Tolstead, E. B., Pittsburg, Pa.
 Vogel, Felix A., New York, N. Y.
 Wright, Charles L., Pittsburg, Pa.
 Wadsworth, M. E., Pittsburg, Pa.
 Watson, R. H., Pittsburg, Pa.
 Wales, S. S., Pittsburg, Pa.
 Weil, T., Pittsburg, Pa.
 Wellman, S. T., Cleveland, Ohio.
 Wellman, Mrs. S. T., Cleveland, Ohio.
 Wilson, E. R., Scranton, Pa.
 Young, C. M., Lawrence, Kan.

Pressure-Fans vs. Exhaust-Fans.

Discussion of the paper of Audley H. Stow, presented at the New Haven meeting, February, 1909, and printed in *Bulletin No. 26*, February, 1909, pp. 181 to 195.

R. V. NORRIS, Wilkes-Barre, Pa. (communication to the Secretary*):—Mr. Stow's paper presents a series of arguments, numbered from 1 to 18, concerning the relative merits of four systems of colliery-ventilation, designated by the author as "plain pressure-ventilation," "plain exhaust-ventilation," "obstructed pressure-ventilation," and "obstructed exhaust-ventilation." These arguments are subsequently compared by means of tables, in which an arbitrary numerical value is assigned to each, and which consequently serve no other purpose than that of showing his opinions and predilections, as indicated by his assignment of the said numerical values. In addition to this general summary, Mr. Stow intimates his preference for a fifth method of colliery-ventilation—namely, what he calls "alternating pressure-ventilation," which consists in the running of the fan at "pressure" during working-hours, and as an "exhaust" between shifts—a system which he proposes as, perhaps, new, yet which he thinks deserves recognition "as a standard form."

This proposed "standard form" is not to be found in practice; and I think it would be impracticable in gaseous mines of large extent, for the following reasons:

1. It takes considerable time to reverse the air-current in a large mine; and the reversal would involve a period of complete stoppage of ventilation, long enough to permit serious accumulations of gas.

2. In shaft- and slope-mines, at least, it is hardly practicable to have "every man out of the mine" during the night, and certainly impracticable to avoid keeping mules and horses inside.

* Received Feb. 14, 1910.

3. The doors necessary to divide and direct the air-current are properly hung to open against the air-pressure; and, unless these were secured, a reversal of the fan would not result in a complete reversal of the ventilating-current, but only in a short-circuiting, with probabilities of accumulation of gas at many points. Moreover, there would be danger that important doors, blown open by the reversal, would remain open at the resumption of regular ventilation, thereby disarranging the entire circulation and inviting disastrous explosions.

The calculation under No. 3, in favor of this "standard" method, is based, as the author says (p. 186), on extreme figures; in fact, upon figures so extreme as to vitiate his conclusions. If old workings covering a square mile, with 50 per cent. removed, have an open space of 100,000,000 cu. ft., they must be fully open, and could and should be properly ventilated; whereas, if such workings have closed, there would be no such open area, and, further, the movement of air or gas contained in them would be relatively very slow, and the "breathing" proposed would have a relatively small effect.

With regard to Mr. Stow's eighteen "arguments," the following comments appear to be warranted:

"A. AGAINST PLAIN PRESSURE-VENTILATION."

"1. *The traveling and haulage in the return-current, required by plain pressure-ventilation, are objectionable.*"

The discussion of this proposition is generally correct, except that locomotive-haulage is properly performed in a special split of air, and not in the general return; and that the difference in temperature between the fire-box of a locomotive and the electric arc is absolutely immaterial. Either will surely fire gas.

"2. *In winter there is serious risk, with plain pressure-ventilation, of the air-course freezing-up at a critical moment and possibly causing an explosion.*"

The question of freezing in the intake, especially in shaft-mines, is a serious one, and applies equally to both pressure- and exhaust-ventilation. I cannot agree to the proposition that the accumulation of ice induced in the hoisting-shaft during the night would be "merely a question of small expense and not of danger." Unfortunately, there have been a number of fatal accidents due to this cause.

"3. Pressure-fans are objectionable on the score of possible breakdowns."

It is not clear that the small difference in pressure between exhaust- and pressure-ventilation has much effect in drawing the gases out of the solid; and I think the effect of the sudden breakdown of the only fan on a gaseous mine would be so serious that the type of ventilation in use would be insignificant in comparison.

Duplicate fans are certainly warranted in all cases on gaseous mines, and the insurance thereby secured should not be considered an "unnecessary burden." I see no reason why an exhaust-fan could not be reversed as well as a pressure-fan, at night or at any other time, should such a course be desirable.

"4. Pressure-fans are more liable to be wrecked in case of explosions."

No fan should be so installed as to be liable to damage from explosion; and the relative damage to the two types would depend upon the location and course of the explosion, not on the type of the fan.

"B. IN FAVOR OF PLAIN PRESSURE-VENTILATION."

"5. Positive or pressure-fans hold 'gas-blowers' in check better than exhaust-fans."

In my judgment, this argument is without importance.

"6. Pressure-fans have the advantage in times of falling barometer."

This is not proved. The author suggests staying out of the mines until the barometer gets through falling; the safest course would be to stay out of the mines altogether. The final clause of his discussion would apply as well to suction-ventilation, and forms merely an argument against the driving of fans by constant-speed motors.

"7. Positive or pressure-fans keep fires in check better than exhaust-fans."

The discussion is entirely correct; but the author might have added that reversing the current is often advantageously employed in fighting a mine-fire.

"8. Under plain pressure-ventilation, when the air is properly split, an explosion should be less disastrous."

I would say that, under any type of ventilation, when the

air is properly split an explosion should be less disastrous. May we not assume that this paper is discussing properly-handled ventilation, which presupposes proper splitting?

"9. *In shallow mines, pressure-fans may force considerable volumes of gas to the surface through pillar-breaks.*"

This properly refers to mines worked to the crop, and not necessarily shallow. In such cases, the loss of air with pressure-ventilation may be very serious, and, for this condition, forms one of the strongest arguments against, not for, pressure-ventilation.

Nos. 10 and 11 have, in my judgment, no practical importance.

"C. AGAINST PLAIN EXHAUST-VENTILATION."

"12. *Exhaust-fans necessitate, in winter, the daily removal of ice from the drift-mouth, or the hoisting-shaft, as the case may be.*"

This is fully referred to under argument No. 2.

"13. *Exhaust-fans, in winter, make the temperature uncomfortable at the head of the hoisting-shaft.*"

This is more than counterbalanced by the fresh air and freedom from smoke, gases, and dust at the foot of the hoisting-shaft, which should properly be put among the arguments for exhaust-ventilation.

"14. *In shallow mines, exhaust-fans may draw into the live workings considerable volumes of gas which would otherwise find their way, through pillar-breaks, to the surface.*"

Under these conditions exhaust-fans will draw in from the surface considerable volumes of fresh air, increasing the quantity in circulation, and decreasing the frictional resistance. Within limits, this is a decided advantage.

"15. *Exhaust-fans not only keep much the larger portion of the haulage-dust in the mine, but distribute it throughout the workings.*"

Since this argument received preponderating weight in Tables I. and IV., for bituminous mines, it is unfortunate that "lack of space" precluded the adequate discussion indicated. It would have been valuable to have had a classification of dust in respect to its origin and position; for it does not seem clear that the greater part is "haulage-dust." In fact, most dust-explosions seem to have started at the face, and it is at least possible that the dust due to blasting may have been a contributing cause. Should the blasting-dust prove to be the

controlling factor, of course the argument is reversed to favor exhaust- instead of pressure-ventilation.

“D. IN FAVOR OF PLAIN EXHAUST-VENTILATION.”

Except No. 16, to which the author properly gives no value, all arguments in favor of exhaust-ventilation, which (I may incidentally say) is the usual method in the anthracite-regions, appear only as arguments against pressure-ventilation; and a very important argument in favor of exhaust-ventilation is not referred to—namely, the presence of fresh and safe air at the foot of the hoisting-shaft or slope, giving a better chance for escape in case of accident or explosion, and permitting adequate lighting at this most important point.

Nos. 17 and 18.—Obstructed ventilation, involving the use of ventilating-doors or their equivalent at the drift- or shaft-mouth, while not fatally objectionable in drift-workings, presents, in shaft- or slope-hoisting, a problem so serious that no engineer would be warranted in using the method except as a temporary expedient.

Conservation of Natural Resources.

Discussion of the paper of James Douglas, presented at the New Haven meeting, February, 1909, and published in *Bulletin No. 29*, May, 1909, pp. 439 to 451.

JAMES DOUGLAS, New York, N. Y. (communication to the Secretary*):—In my paper on the Conservation of Natural Resources, I referred to the slow replacement of bee-hive ovens by the by-product ovens as a most notable instance of waste. And I quoted from Mr. Parker's report for 1906 an explanation given by him in accounting for the small production of by-product coke. It was that the markets for the by-products of the coke-ovens was so limited that some of the ovens constructed were out of operation. His report on the manufacture of coke in 1908¹ does not record an improvement, and attributes the strange fact that we alone, of all the [industrial peoples, delay the adoption of this cardinal improvement from the continuance of the same almost inexplicable cause. To quote again from his report, he says (p. 241):

"The year 1908 was not marked by any notable gain in the construction of by-product coking plants, though some new work was done. There was a net increase of 115 in the number of completed ovens in 1908 over 1907, the totals for the two years being, respectively, 3,892 and 4,007. The additional equipment consisted of 140 Koppers regenerative ovens built at Joliet, Ill., by the United States Steel Corporation, but this increase was partly offset by the dismantling of 25 Semet-Solvay ovens at Sharon, Pa., the net gain being 115 ovens. Included in the total of 4,007 completed ovens in 1908 are 152 Newton-Chambers ovens at Vintondale, Pa., but as no recovery of by-products was made at this plant in 1908, the production of coke is included with that from beehive ovens. The 56 ovens of the same type at Pocahontas, Va., have not been in practical operation since they were first installed. In addition to these there was one other by-product plant of 120 ovens that was not operated during the year. The number of retort ovens producing coke in 1908 was 3,679, as compared with 3,811 active ovens in 1907."

In describing the anomaly he says (p. 249):

"It has been contended that the development of the by-product coking industry would have shown more rapid progress if markets for the by-products were

* Received Feb. 2, 1910.

¹ *Mineral Resources of the United States for 1908*, Part II., U. S. Geological Survey (1909).

assured. This pertains essentially to the coal tar and its products, as there is no difficulty in disposing of the surplus gas, and there is practically at all times a fair demand for ammonia. As to the coal tar, the total value of this by-product from retort ovens at first hand in 1908 was \$1,007,613. The value of the coal-tar products imported into this country in 1908, including duty paid, was \$8,560,406. The values in all cases of imports are at point of shipment, and do not include ocean freights, commissions, and other expenses. It is probable that these importations have reached the consumer at a total cost of not less than \$12,000,000, and in the three preceding years the cost probably reached \$15,000,000."

These coal-tar products, however, which are imported into the United States at such a heavy figure, are all chemical extracts from coal-tar, such as salicylic acid, aniline dyes, and alkaline salts, the manufacture of which has passed in great measure into German hands. Some peculiar attribute of the German temper, and the thorough character of their technical educational methods, have given them a monopoly of this delicate branch of the chemical industry. Even England, where originated the manufacture of the coal-tar products, and where the first patents were taken out, has been unable to compete with her more precise and painstaking rival.

As the utilization of the tars is therefore the function of the chemical manufacturer, and the production of the crude material alone falls to the coke-maker, the one industry must keep pace with the other if progress along either line is to be made. As the profits of certain European coking-plants collecting the by-products are generally supposed to be from \$0.75 to \$1.25 per ton of coke on the by-products alone, it would seem as though capital, skill, and science could not be more profitably employed in the United States than in removing this crying disgrace by turning the waste products from our coking establishments to such profitable use.

With regard to what will happen in the distant future when our coal-supply is exhausted, Dr. Robert Thomas Moore, in his presidential address² before the Institution of Mining Engineers in London on May 27, 1909, says (p. 455):

"Whether, indeed, it is a profitable matter to attempt to imagine the state of Britain 300 years after this, with its coal exhausted, or a world, say, 200 years later when it is all finished, is open to question. It is certainly beyond the scope or the objects of the Institution.

² *Transactions of the Institution of Mining Engineers*, vol. xxxvii. (1903-09).

"I do not think it commends itself as an economic principle to restrict in any way the legitimate development of our mineral resources. They are a source of wealth to ourselves, and we are helping to develop the world. Is it not more reasonable to trust to the progress of science to discover some fresh method of utilizing the resources of nature to provide a substitute? Who would have expected, even 30 years ago, the immense possibilities for distributing light and heat and power that the development of electricity has opened up? We have the forces of the rainfall, the wind, and the tides to utilize to the utmost. We may even get our heat and power direct from the sun!

"Those who come after us have a long time in which to consider the problem, and we may safely leave it to them to solve in their own way.

"But that of which we should be careful is, that we should use our coal in the best possible manner—that in the working of it and in the using of it there should be no waste, either of men, of material, or of treasure; and it is the duty of an Institution such as ours to afford every aid to the presentation of any plan which will further the attainment of these objects."

His remarks upon the ever-increasing consumption of coal, despite the efforts of the engineer to economize, are worthy of quotation. He says (p. 453):

"It is a striking fact that notwithstanding all the improvements which have been introduced to economize coal in the various industries, the total consumption has gone on increasing. It seems as if the greater the economy becomes the larger is the consumption.

"There have been atmospheric engines, Watt's condensing engines, high-pressure engines, compound engines, triple- and quadruple-expansion engines, turbines, and gas-engines, each being an improvement on its predecessor, until the coal consumed per horsepower per hour has been reduced from over 10 pounds to $\frac{1}{4}$ pound; the methods of iron-smelting have been improved until the amount of fuel used has been reduced from 8 tons per ton of pig-iron to considerably under 2 tons; the processes for the manufacture of gas have been improved; and the whole history of the century has been a long series of savings in fuel. Yet the total consumption goes on steadily increasing. It would seem that the more the cost of power is cheapened, the more are the purposes for which it becomes available."



Genesis of the Lake Valley, New Mexico, Silver-Deposits.

Continued discussion of the paper of Charles R. Keyes, *Trans.*, xxxix., pp. 189 to 169, 850 to 856, and *Bulletin No. 34*, October, 1909, pp. 945 to 947.

CHARLES R. KEYES, Des Moines, Iowa (communication to the Secretary*):—It is with pleasure that I acknowledge the value and interest of the historical notes on early mining at Lake Valley, contributed by Messrs. MacDonald and Courtis. In my own paper there was no attempt to enter into this phase of the subject; partly for reason that the intention was to take up this in detail in another connection, partly because there was not space enough to devote to it in a brief geologic paper, and partly on account of the fact that the strictly mining features are quite distinct from the purely geologic characteristics.

As may be inferred from its perusal, the brief historical paragraph prefacing my paper was in reality geologic in its bearing. The events referred to therein relate to the published information concerning the geologic structure. The personages principally mentioned were noted merely to show how the names of several of our most distinguished scientists came to be closely associated with that of Lake Valley.

Far from my intentions was it to slight the memory of any of that brave band who, with lives in their hands, took so active a part in the early development of the mines. The value of their records is perhaps much greater than that of any published notes. The narratives of Messrs. MacDonald and Courtis are as thrilling as many other experiences related of that time and place. Few of us at the present time can appreciate the dangers of that early day, when the fierce Apache all but swept the white man from that part of the country, when renegades from Texas overran the land, and when the outlaws of the nations took their last stand before advancing civilization. In marked contrast do we to-day reach Lake Valley by means of the "iron horse"; and out of a luxurious Pullman

* Received Jan. 10, 1910.

palace-car literally step directly into the famous Bridal Chamber of the Grande mine.

We are greatly indebted to Messrs. MacDonald and Courtis, especially since their accounts clear up certain hitherto obscure relationships of the various workers in the camp. At this distant day the spoken records are apt to be dimmed and inaccurate. At the same time, by other authenticated records, features are presented from an entirely different view-point. From all, a tolerably complete picture is obtained of the events during the most strenuous period of the Southwestern country. In the near future I hope to present some of the salient historical features of New Mexican mining. Lake Valley bears an important part.

The Cyaniding of Silver-Ores in Mexico.

Discussion of the paper of Albert F. J. Bordeaux, presented at the Spokane meeting, September, 1909, and published in *Bulletin No. 37*, January, 1910, pp. 51 to 62.

HERBERT A. MEGRAW, San Luis de la Paz, Guanajuato, Mex. (communication to the Secretary*) :—Although Mr. Bordeaux prefaces his paper with the statement that it is a general outline of practice in the Republic, many of his statements seem to be made from the view-point of a particular case, which does not always agree with general practice. For the purpose of calling attention to some of these variations, I respectfully offer the following comments :

The operation of crushing and grinding is performed by so many different methods and systems that it is useless to select any one as the standard. However, primary crushing in rock-breakers followed by stamps is thus far so general that it might be so classified. Whether or not it is the best way is open to question. Regrinding may be performed by any of the various types of Chilean mills, Huntington mills, or similar machines, or the material may be taken directly from the stamps and delivered to the tube-mills.

Mr. Bordeaux's statement that "the slimes can be treated only by decantation; the new Butters slime-filter, as used in Nevada, does not seem to be successful with silver-ores," is surely an error. All over Mexico many of the purely silver-ores are being successfully handled by the Butters or similar filters, such as the Moore and the Burt filters, and a letter to the manufacturers of these filters will undoubtedly bring a list of the silver-ores now being successfully treated in this way.

The statement that crushing silver-ores in solution is impossible is equally erroneous. Most modern mills crush the ore in solution, in some cases containing as much as 0.12 per cent. of KCN. I cannot for the moment recall any modern mill in Mexico which does not follow this practice. There may be

some reason for it in particular instances, but, generally speaking, the practice is to crush in solution. Care in installation avoids any mechanical loss of cyanide, and the chemical loss is so small as to be negligible.

The method of treating sands as indicated by Mr. Bordeaux—namely, first a weak wash, then strong washes, and finally another weak wash—seems to me to be best adapted to particular instances in which it is necessary to avoid large chemical-consumption. The general practice is to use the strong solution immediately after draining the tanks of their filling solution, and to follow with the weak washes.

The statement that the new Pachuca tank treats sand and slime together seems to me to require some modification, since it is only true when the sand has been so finely ground that it may be fairly easily kept in suspension by the agitating-power of the compressed air. So far as I am aware, no attempt has been made to agitate coarse sand. The cost of power and treatment would preclude economical results.

The costs given for crushing and sand-treatment, \$4.50 U. S. currency, seem abnormally high. Referring to Ferdinand McCann's book,¹ in which costs are given for many large mills in Mexico, this cost seems to be about half the amount stated by Mr. Bordeaux, and in some cases even less.

At Guanajuato, the use of stationary air-pipes in the bottom of the tank for agitating slime-charges has been discontinued for more than a year.

The reference to the new tanks at Pachuca as "Grothe" tanks is apparently an error, unless some new development has taken place. The general description answers to that of the Brown or Pachuca tank, which was invented and used first in New Zealand, and first introduced in Mexico at Pachuca. The patentee of the tank is represented in Mexico by the firm of Grothe & Carter, of which firm Mr. Grothe is the head. Probably the name Mr. Bordeaux uses was derived in this way. Mr. Bordeaux neglects to state by what means the clear solution is decanted from the Pachuca tank.

In comparing the advantages of shipping bars or precipitates, Mr. Bordeaux has received the impression that the government

¹ *Beneficio de Metales de Plata y Oro por Cianuracion* (1909).

tax is higher on bars, thus making it advantageous to ship precipitates. This is an error, as I am reliably informed that the government tax is levied on the metal-content of any product, and is thus the same on gold and silver whether in the shape of bars or contained in precipitates, concentrates, or ores. This apparently gives the advantage to the bars, since less weight has to be transported.

The Nicola Valley Coal-Field, British Columbia.

POSTSCRIPT.

BY MILNOR ROBERTS, SEATTLE, WASH.

(Spokane Meeting, September, 1909.)

POSTSCRIPT (Mar. 16, 1910).—The daily production of coal in the Nicola valley has increased somewhat during the past winter and development-work has continued. The coal appears to be suited to the use of the coal-cutting machines that were installed last fall. The railroad situation has improved materially, largely as a result of the election held in November. The provincial government of British Columbia has given aid to the construction of the Nicola branch of the Canadian Pacific railway southeastward from Nicola through Penticton to Midway, the present terminus of the branch leading from the east. The Vancouver, Victoria & Eastern Railway & Navigation Co. has let contracts to extend the road on the western side of the Cascade mountains from Abbotsford to a point near Hope, and, on the eastern side, from Princeton to Otter Flat, leaving a gap of about 60 miles to be completed across the summit of the range east of Hope. Regarding the Canadian Northern railway, bonds to the amount of \$35,000 per mile have been voted for its construction from Vancouver up the Fraser, Thompson, and North Thompson rivers to Yellowhead pass. Right-of-way, town-sites, and timber for construction purposes have been granted free wherever the road traverses crown lands. The southern branch of the Grand Trunk Pacific now seems likely to follow a route considerably west of Nicola valley.

General References: *Report on the Mining and Metallurgical Industries of Canada*, 1907-8, pp. 260 to 271. Canada, Department of Mines, Mines Branch, Ottawa (1909).

Annual Report of the Minister of Mines, British Columbia, for 1905, pp. J196 to J201. Victoria, B. C. See also reports for later years.

Summary Reports of Geological Survey Branch of Department of Mines, for 1904 and later years. Ottawa.

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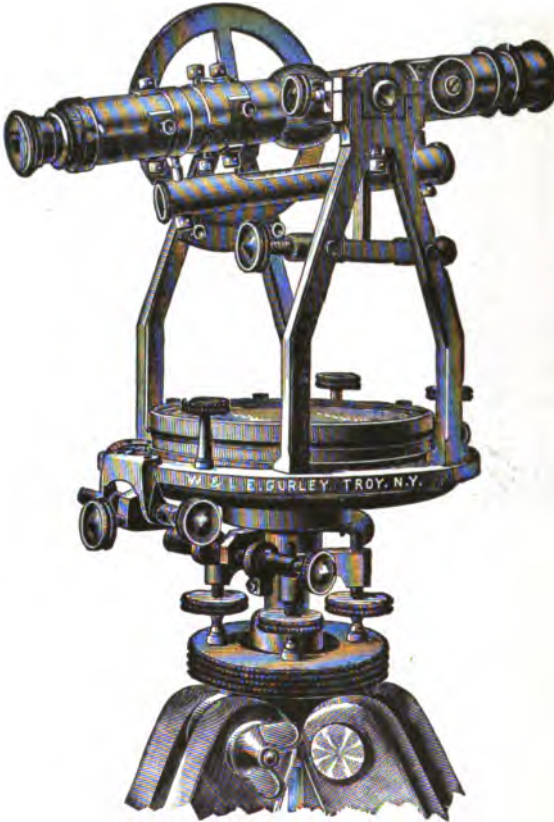
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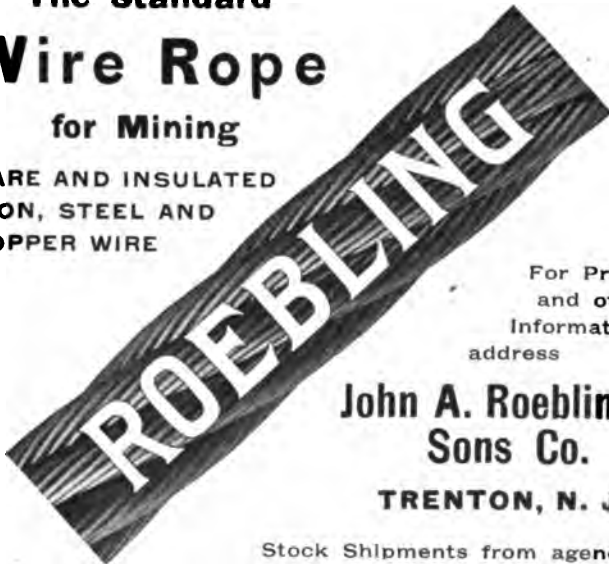
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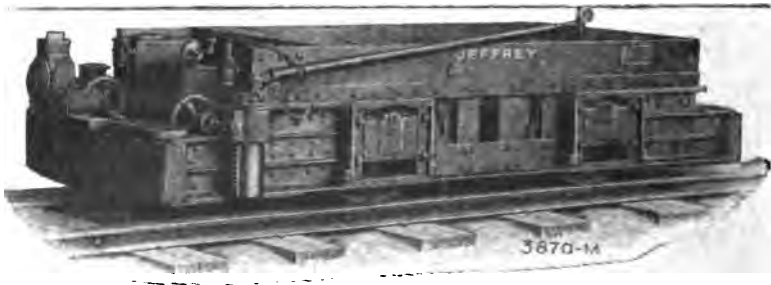
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BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

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SECTION I.—INSTITUTE ANNOUNCEMENTS.

This section contains announcements of general interest to the members of the Institute, but not always of sufficient permanent value to warrant republication in the volumes of the *Transactions*.

SECTION II.—TECHNICAL PAPERS AND DISCUSSIONS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

A detailed list of the papers contained in this section is given in the Table of Contents. They have been so printed and arranged (blank pages being left when necessary) that they can be separately removed for classified filing, or other independent use.

A small stock of separate pamphlets, duplicating the technical papers given in Section II. of this Bulletin, is reserved for those who desire extra copies of any single paper.

Comments or criticisms upon all papers given in this section, whether private corrections of typographical or other errors or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.

All communications concerning the contents of this Bulletin should be addressed to Dr. Joseph Struthers, Assistant Secretary and Editor, 29 W. 39th St., New York, N. Y. (Telephone number 4600 Bryant).

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For the year ending February, 1911.

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* SECRETARY'S NOTE.—The Council is the professional body, having charge of the election of members, the holding of meetings (except business meetings), and the publication of papers, proceedings, etc. The Board of Directors is the body legally responsible for the business management of the Corporation, and is therefore, for convenience, composed of members residing in New York.

INSTITUTE ANNOUNCEMENTS.

The Raymond Anniversary Dinner.

On the evening of April 30, a memorable tribute was given to Rossiter Worthington Raymond, Ph.D., LL.D., Vice-President and acting President of the American Institute of Mining Engineers in 1871; President in 1872, 1873, and 1874; Vice-President in 1876 and 1877; and Secretary since 1884, in the form of a dinner at the Plaza Hotel in New York City, in celebration of the 70th anniversary (April 27) of his birthday. Although this celebration was originally proposed by members of this Institute, it was found impossible to limit it in that way, and in response to protests and demands from other societies and from individuals, it ultimately became a gathering of Dr. Raymond's friends. The cherished tradition of the Institute, to include ladies at the tables of its banquets, was, however, preserved, and of the 250 present, about one-third were of the gentler sex. Dr. James Douglas, past-President of the Institute, presided. Mr. E. G. Spilsbury, past-President of the Institute, and Chairman of the Committee, read numerous letters and telegrams from all parts of the United States and abroad, and presented engrossed and illuminated congratulatory messages from the Iron and Steel Institute and the Association of German Ironmasters; Mr. Rawlinson T. Bayliss, Vice-President of the Institution of Mining and Metallurgy (London, Eng.), presented, with appropriate and graceful remarks, the Gold Medal of that Society; M. Sorzano de Tejada, delegate of the Society of Civil Engineers of France, presented the resolutions of the Council of that Society (of which Dr. Raymond has been for many years an Honorary Member). Dr. Andrew Carnegie, Honorary Member of the Institute and past-President of the Iron and Steel Institute, and Mr. C. J. Partington, Vice-President of the Mining Society of Nova Scotia, who had expected to be present, sent cordial messages of regret and congratulation. Addresses were made by the Rev. Lyman Abbott, D.D.; Mr,

Frank Dawson Adams, President of the Canadian Mining Institute; Messrs. John A. Benschel, President of the American Society of Civil Engineers; George Westinghouse, President of the American Society of Mechanical Engineers; Robert W. Hunt, past-President of the American Institute of Mining Engineers; and T. Commerford Martin, past-President of the American Institute of Electrical Engineers, who spoke not only as representatives of their respective societies and professions, but also as personal friends of the guest of the evening. A peculiarly beautiful feature of the programme was the address to Mrs. Raymond by Mr. W. L. Saunders, Vice-President of our Institute, accompanied with 47 "American Beauty" roses, one for each year of her married life. Dr. Douglas followed with felicitous remarks, leading up to the dramatic climax of the evening. At his signal, a clever paste-board imitation of a Western mountain, with surface-indications of mine-buildings, hoisting-machinery, tramways, etc., parted in the middle, as by a peaceful earthquake, and disclosed a magnificent silver table-service, which was presented to Dr. and Mrs. Raymond.

A few brief but affecting remarks from Dr. Raymond terminated the exercises.

It is understood that the Committee in charge of this dinner intends to print and send to each participant a full account of the proceedings, including a report of the various addresses.

Canal Zone Meeting.

As already announced in Circular No. 2 from the office of the Secretary, dated April 20, 1910, the Council has authorized a meeting of the Institute to be held next autumn in the Canal Zone. The following letter from the President of the United States, together with unofficial communications from Colonel Goethals, the Engineer in Charge, assures the Institute of a cordial reception and a profitable as well as delightful excursion:

THE WHITE HOUSE.

WASHINGTON, April 12, 1910.

My Dear Sir: Having been informed that the Council of your Institute is considering the advisability of holding an excursion meeting in the Canal Zone in the autumn of this year, it gives me great pleasure to express my personal hope

that this plan be carried out and I promise to extend, on the part of the administration, a cordial welcome to the Institute and every practical co-operation with the object of their visit.

Trusting that your members will find both time and opportunity to make a study of the conditions under which this work is carried on, the rate of progress which is now being attained and the immense value of the undertaking to the people of this country, I am,

Sincerely yours,

(Signed) WM. H. TAFT.

DR. R. W. RAYMOND, *Secretary*,
American Institute of Mining Engineers,
29 West 39th Street, New York.

Concerning this meeting, the following preliminary statement is offered:

1. The party will leave New York about the beginning of November; the trip will occupy between three and four weeks; and the cost to each passenger will be about \$200, covering hotel-expenses and transportation on the Isthmus.

2. Besides the trip to and from the Isthmus, it is proposed to include, among other possible stops *en route*, a visit to the mines and works of the Spanish American Iron Co., on the north shore of Cuba. It is probable that other points, such as Havana, Kingston, etc., will be touched. But information as to all these details can be given only after the reception from members of the return cards sent with the circular has permitted the making of definite arrangements.

3. According to present information, the number of members and guests (including ladies) who can be transported at the rate stated above is 150. This number can be accommodated upon one of the regular Hamburg-American steamers, if ample notice be given in advance to secure reserved rooms.

Members who contemplate taking the trip, and have not yet notified the Secretary, are requested to indicate without delay their intention concerning the Canal Zone meeting. To those replying in the affirmative special circulars will be subsequently sent concerning all necessary details; and, if the number of members and guests thus indicated should exceed 150 (without amounting to an aggregate so large as to require an entirely new arrangement), the following order of preference will be observed:

Up to May 15, preference will be given to members in the order of the date of their applications; then to guests of members in like order, one guest for each member having preference if the accommodations are overcrowded; after May 15, both members and guests in the order of application.

International Congress for Mining, Metallurgy, Applied Mechanics, and Practical Geology, Düsseldorf, June, 1910.

A full account of the organization of the Congress, including rules of membership, classification of papers, time of presentation, length, etc., will be found in *Bulletin* No. 37, January, 1910; and a detailed list of the papers to be presented, together with the program of the visits and excursions, was printed in *Bulletin* No. 40, April, 1910.

A recent circular from the Secretary of the Congress, Dr. E. Schroedter, advises that the number of applications for membership up to Feb. 1, 1910, had reached the very satisfactory total of 750, of which one-third was from foreign countries. From this excellent showing at so early a date before the meeting it is reasonable to expect that there will be a large attendance at the meeting.

The official representatives of the Institute at the Congress are Mr. Charles Kirchhoff, past-President, and Mr. Edward W. Parker, past-Councilor, who are authorized to express on that occasion the cordial greetings of the Institute to its professional colleagues beyond sea.

Meetings of Other Societies.

The American Society of Mechanical Engineers.—The Spring Meeting of the American Society of Mechanical Engineers will be held at the Marlborough-Blenheim Hotel, Atlantic City, May 31 to June 3, 1910.

The Local Committee, under the chairmanship of James M. Dodge, past-President American Society Mechanical Engineers, President of the J. M. Dodge Co., Philadelphia, Pa., is arranging for the entertainment of those in attendance.

On Thursday evening, June 2, Honorary Membership will be conferred upon Rear-Admiral George W. Melville, U. S. N., Ret., and a brief address will be made by Admiral Melville.

The Meetings Committee has provided for professional sessions on Machine Construction and Operation, Gas Power, Power Transmission and Miscellaneous Subjects, with papers on The Shockless Jarring Machine, by Wilfred Lewis; A Com-

parison of Lathe Headstock Characteristics, by Prof. Walter Rautenstrauch; The Strength of Punch and Riveter Frames made of Cast Iron, by Prof. A. L. Jenkins; Improved Methods in Finishing Stay Bolts and Straight and Taper Bolts as Used in Locomotives, by C. K. Lassiter; The Mechanical Engineer and the Textile Industry, by H. L. Gantt; The Elastic Limit of Manganese and other Bronzes, by J. A. Capp; The Hydrostatic Chord, by R. D. Johnson; The Resistance of Freight Trains, by Prof. Edw. C. Schmidt; A Regenerator Cycle for Gas Engines Using Sub-Adiabatic Expansion, by Prof. A. J. Frith; Gas Engines for Driving Alternating Current Generators, by H. G. Reist; Two Proposed Units of Power, by Prof. Wm. T. Magruder; Some Operating Experiences with a Blast-Furnace Gas Power-Plant, by H. J. Freyn; Improvements in Lineshaft Hangers and Bearings, by Henry Hess; Experimental Analysis of a Friction Clutch Coupling, by Prof. Wm. T. Magruder; An Improved Absorption Dynamometer, by Prof. C. M. Garland; and Critical Speed Calculation, by S. H. Weaver.

American Institute of Electrical Engineers.—The annual meeting of the American Institute of Electrical Engineers will be held in the auditorium of the Engineering Societies Building, 33 West 39th Street, New York City, on Tuesday, May 17, 1910. In addition to the business transacted, a paper will be presented by John W. Howell, Engineer, Lamp Works, General Electric Co., Harrison, N. J.

A special meeting, under the auspices of the Railway Committee, will be held in the auditorium of the Engineering Societies Building, on Friday evening, May 27, 1910. The following papers will be presented: The Application of Porcelain to Strain Insulators, by W. H. Kempton; Electric Railway Overhead Construction, by W. N. Smith.

Society for the Promotion of Engineering Education.—The annual meeting of the Society for the Promotion of Engineering Education will be held at Madison, Wis., on Thursday, Friday and Saturday, June 23, 24 and 25. An attractive program has been arranged for the meeting. Among the most important items are the reports of the Committees on Entrance Requirements

and Engineering Mathematics, which will be presented for final action. Copies of the reports in full will be distributed to the membership some weeks in advance of the meeting. Technical Education Abroad, Inspection Trips for Technical Students, Efficiency in Technical Education, and other topics will be presented for discussion. Full information regarding the meeting and the general work of the Society can be secured from Prof. H. H. Norris, Cornell University, Ithaca, N. Y.

Members of the American Institute of Mining Engineers are cordially invited to attend these meetings.

How to Use the "Transactions" of the Institute.

Buy a copy of the Complete Analytical and Alphabetical Index of Volumes I. to XXXV., inclusive.

If you own a full set of the *Transactions*, this Index will make the whole of it instantaneously available without detailed research into each volume separately.

If you do not own such a set, this Index will be even more valuable, for it will show you what particular papers you need to know more about, and perhaps to study. Thus, any person possessing this Index can ascertain at once what has been published in the *Transactions* on a given question, and can learn, by writing to the Secretary, what is its nature, whether it is still to be had in pamphlet form, where it can be consulted in a public library, at what cost it can be copied by hand, etc., etc.

In short, to those who own complete sets of the *Transactions*, this Index will be a great convenience; but to those who do not, it will be a professional necessity.

This volume is an octavo of 706 pages, containing more than 60,000 entries, duly classified with sub-headings, and including abundant cross-references. It has not been stereotyped, and the edition is limited to 1,600 copies. The price of the volume, bound in cloth, is \$5, and bound in half-morocco to match the *Transactions*, \$6. The delivery charges will be paid by the Institute on receipt of the above price.

Hydrographic Chart.

Owing to the great value to hydrographers of the chart contained in the paper, A Graphic Solution of Kutter's Formula, by L. I. Hewes and Joseph W. Roe (*Bulletin No. 29*, May, 1909, p. 454), a special edition for office or field use has been printed on durable cloth. Copies of this separate chart may be obtained, at a cost of 50 cents each, on application to the office of the Secretary of the Institute.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

AMERICAN INSTITUTE OF MINING ENGINEERS.

UNITED ENGINEERING SOCIETY.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays, from September 1 to June 30, and from 9 A.M. to 6 P.M. during July and August.

RULES.

For the protection and convenience of members, the following rules have been adopted :

The Secretary of each Society will, upon application, issue to any member of his Society in good standing a personal, non-transferable card, entitling him to the use of the Libraries in the alcoves of the Reading-Room. This card must be signed by the person receiving it, and surrendered at the desk at the time of its presentation. At every visit he must identify himself by signing his name in the registry.

The first two alcoves are free to all; and admission to the inside alcoves is given only upon proper introduction.

The above rules apply to all persons except officers of the three Societies, personally known as such to the librarians.

The librarians are not permitted to lend to any person any catalogued pamphlet or volume, unless authorized in writing so to do by the Secretary or Chairman of the Library Committee of the Society to which the pamphlet or volume belongs.

Any person discovering a mutilation or defect in any book of the libraries is requested to report it to the librarian on duty.

Library Accessions.

Apr. 1 to May 1, 1910.

[Copies of the list of additions to the Libraries of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers can be obtained on application to the Secretary of the American Institute of Mining Engineers.]

AMERICAN INSTITUTE OF ARCHITECTS. Proceedings of Annual Convention, 43d, 1909. Washington, 1910. (Exchange.)

ANTIGUA GOLD-COPPER COMPANY. Prospectus. New Orleans, n. d. (Gift of W. Beer.)

ART CLUB OF PHILADELPHIA. Charter, Constitution, and By-Laws, 1910. Philadelphia, 1910. (Gift.)

BROKEN HILL SOUTH SILVER MINING COMPANY. Reports, Statements of Accounts, for Half-Year Ended Dec. 31, 1909. Melbourne, 1909. (Gift of Mr. Wainwright.)

COPPER HANDBOOK. Vol. IX. By H. J. Stevens. Houghton, 1909. (Purchase.)

ECONOMIC GEOLOGY OF THE FELDSPAR DEPOSITS OF THE UNITED STATES. (Bulletin No. 420, U. S. Geological Survey.) By E. S. Bastin. Washington, 1910. (Exchange.)

ENGINEERING STANDARDS COMMITTEE. Report on British Standard Copper Conductors. 2d issue. London, 1910. (Exchange.)

GEOLOGY AND ORE-DEPOSITS OF THE BULLFROG DISTRICT, NEVADA. (Bulletin No. 407, U. S. Geological Survey.) By F. L. Ransome and others. Washington, 1910. (Exchange.)

GEOLOGY OF THE ELIZABETHTOWN AND PORT HENRY QUADRANGLES. (Bulletin No. 138, New York State Museum.) By J. F. Kemp and R. Ruedemann. Albany, 1910. (Exchange.)

INTERNATIONAL AMERICAN SCIENTIFIC CONGRESS. Bulletin No. 1. Buenos Aires, 1910. (Gift.)

JAHRESBERICHT UBER DIE LEISTUNGEN DER CHEMISCHEN TECHNOLOGIE. Band 55. Unorganischer teil, 1909. Leipzig, 1910. (Purchase.)

JOHN CRERAE LIBRARY. Annual Report, 1909. Chicago, 1910. (Exchange.)

MEASUREMENT OF PULP AND TAILING. By W. J. Sharwood. London, 1910. (Gift of Author.)

MEMORIE DESCRITTIVE DELLA CARTA GEOLOGICA D'ITALIA. Vol. XIII. Geologia della Toscana. Di B. Lotti. Roma, 1910. (Gift of R. Ufficio Geologico.)

METAL INDUSTRY DIRECTORY, 1910. New York, 1910. (Gift.)

MINING INDUSTRY IN NORTH CAROLINA DURING 1907. (Economic Paper No. 15.) Raleigh, 1908. (Exchange.)

MISSISSIPPI VALLEY BETWEEN SAVANNA AND DAVENPORT. (Bulletin No. 13, Illinois State Geological Survey.) By J. E. Carman. Urbana, 1909. (Exchange.)

MISSOURI. Geological Map of Missouri, 1907. (Exchange.)

NEW MEXICO. MINE INSPECTOR. Report, 1909. Washington, 1910. (Exchange.)

NOVA SCOTIA. MINES DEPARTMENT. Report, 1909. Halifax, 1910. (Exchange.)

ONTARIO. BUREAU OF MINES. Annual Report, 18th. Vol. 18, Pt. 1, 1909. Toronto, 1909. (Exchange.)

- QUALITY OF SURFACE WATERS IN THE UNITED STATES. Part 1. (Water-Supply Paper No. 236, U. S. Geological Survey.) By R. B. Dole. Washington, 1909. (Exchange.)
- RESULTS OF OBSERVATIONS MADE AT THE COAST AND GEODETIC SURVEY MAGNETIC OBSERVATORY AT SITKA, ALASKA, 1905-1906. By F. L. Hazard. Washington, 1910. (Exchange.)
- STANDARD OIL COMPANY. By Elbert Hubbard. N. p., n. d. (Gift.)
- SUMMARY OF TESTS OF CENTRAL QUEENSLAND COALS. By C. F. V. Jackson. Brisbane, 1909. (Exchange.)
- U. S. CENSUS BUREAU. Seventh Census, 1850. Washington, 1853. (Exchange.)
- Preliminary Report on Eighth Census, 1860. Washington, 1862. (Exchange.)
- Eighth Census, 1860. Agriculture, Mortality, Manufactures, Population. 4 vols. Washington, 1864-66. (Exchange.)
- Ninth Census. Vols. 1-2. Washington, 1872. (Exchange.)
- Compendium of the Ninth Census, 1870. Washington, 1872. (Exchange.)
- Statistics of the U. S. of America. Washington, 1841. (Exchange.)
- Sixth Census, 1840. Washington, 1841. (Exchange.)
- Compendium of the Enumeration of the Inhabitants of the United States. Washington, 1841. (Exchange.)
- Mortality Statistics of the Seventh Census, 1850. Washington, 1855. (Exchange.)
- Report of the Superintendent, Dec., 1852. Washington, 1852. (Exchange.)
- Statistics of Cities Having a Population of Over 30,000, 1907. (Special Reports.) Washington, 1910. (Exchange.)
- U. S. CIVIL SERVICE COMMISSION. Annual Report, 1st, 10th, 11th, 12th, 13th, 19th, 24th. Washington, 1884, 1894, 1895, 1897, 1902, 1908. (Gift of U. S. Civil Service Commission.)
- U. S. COAST AND GEODETIC SURVEY. Report of Superintendent, 1897. Washington, 1897. (Exchange.)
- U. S. ENGINEERS, CORPS OF. Professional Memoirs. Vol. 2, No. 6-date. Washington, 1910. (Exchange.)
- U. S. INTERSTATE COMMERCE COMMISSION. Annual Report on the Statistics of Railways. 1888, 1891-1895, 1897-1900. Washington, 1899-1901. (Exchange.)
- U. S. LIGHT HOUSE BOARD. Annual Report, 1876-1878, 1880-1881. Washington, 1877-1878, 1880-1881. (Exchange.)
- U. S. NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS. Proceedings of Annual Convention, 1901-1908. Washington, 1901-1909. (Exchange.)
- U. S. ORDNANCE DEPARTMENT. Report on the Test of Metals, 1894, 1895. Washington, 1895, 1896. (Exchange.)
- U. S. RECLAMATION SERVICE. Annual Report, 1902, 1902-1903, 1908-1909. Washington, 1903, 1904, 1910. (Exchange.)
- U. S. SIGNAL OFFICE. Annual Report of the Chief, 1870, 1871, 1873, 1874, 1882, Pts. 1-2; 1886, 1887, Pts. 1-2; 1888, 1889, Pts. 1-2; 1890, 1891. Washington, 1870-1891. (Exchange.)
- U. S. WAR DEPARTMENT. Annual Report of the Chief of Engineers, 1905, Vols. 5-8; 1906, Pt. 2; 1908, Pts. 1-3; 1909, Pts. 1-3. Washington, 1905, 1906, 1908-1909. (Exchange.)

U. S. WEATHER BUREAU. Special Report of the Chief, 1891. Washington, 1891. (Exchange.)

— Report of the Chief, 1891, 1892, 1895, 1891-1892, 1895-1896, 1897-1898, 1899-1900, 1900-1901, Vols. 1-2; 1907-1908. Washington. 1892, 1893, 1895, 1896, 1899, 1901, 1902, 1909. (Exchange.)

UNIVERSITY OF OREGON. Announcements, 1910. Eugene, 1910. (Exchange.)

TRADE CATALOGUES.

A. S. CAMERON STEAM PUMP WORKS, New York, N. Y. Catalogue No. 36. Cameron pumps, plunger pumps, sinking pumps, piston pumps, etc. 157 pages.

COLORADO IRON WORKS Co., Denver, Colo. Pamphlet No. 9B. The impact screen. 11 pages.

GENERAL ELECTRIC Co., Schenectady, N. Y.

Price List No. 5214. G. E. Edison carbon incandescent lamps. 7 pages.

Price List No. 5218. G. E. train-lighting lamps. 3 pages.

Mazda versus tungsten lamps. 7 pages.

Bulletin No. 4716. Thomson watt-hour meters with prepayment attachments for direct and alternating currents. 7 pages.

Bulletin No. 4719. G. E. fan motors and small power motors. 36 pages.

GOLDSCHMIDT THERMIT Co., New York, N. Y. *Reactions*, First Quarter, 1910, a quarterly periodical devoted to the science of aluminothermics. 20 pages.

FREDERIK C. GUERBLICH, Long Island City, N. Y. Hoisting and conveying machinery. 32 pages.

JEFFREY MFG. Co., Columbus, Ohio. Bulletin No. 39. Jeffrey roll crushers. 15 pages.

PHOENIX IRON WORKS Co., Meadville, Pa.

Compound self-oiling, automatic cut-off steam-engines. 19 pages.

Simple, self-oiling, automatic steam-engines. 15 pages.

Steam-boilers of all types. 17 pages.

ROY & TITCOMB, Nogales, Ariz. Multiple cylinder, gasoline geared hoisting-engines. 3 pages.

UNIVERSAL PORTLAND CEMENT Co., Chicago, Ill. *Monthly Bulletin* No. 70, March, 1910, a publication in the interest of Portland-cement users. 15 pages.

United Engineering Society Library.

DESIGNING AND DETAILING OF SIMPLE STEEL STRUCTURES. By C. T. Morris. Columbus, 1909. (Gift of Engineering News Publishing Co. Price, \$2.25 net. Contents: Chapter I., Riveting. Chapter II., Designing and Estimating. Chapter III., Manufacture and Erection. Chapter IV., Roofs. Chapter V., Plate Girder Bridges. Chapter VI., Pin-Connected Bridges. Chapter VII., Details of Pin-Connected Bridges.

ELECTRIC POWER PLANTS. By T. E. Murray. New York, 1910. (Gift of Author.)

ENGINEERING INDEX, 1909. New York, 1910. (Purchase.)

INTERNATIONAL WHO'S WHO, 1910-1911. New York, International Who's Who Publishing Co., 1910. (Purchase.)

NEW PRONOUNCING DICTIONARY OF SPANISH AND ENGLISH LANGUAGES. By M. Velazquez de la Cadena. New York, Appleton & Co., 1909. (Purchase.)

POOLE'S INDEX TO PERIODICAL LITERATURE. Vol. 6, 1902-1906. Boston, Houghton, Mifflin & Co., 1908. (Purchase.)

GIFT OF SCHNEIDER & Co.

ACIER AU MANGANESE, PROPRIETES ET APPLICATIONS. (Extrait du *Journal le Genie Civil*. Paris, 1908.

ACIERS SPECIAUX POUR PIECES D'AUTOMOBILES. Objects exposes. Paris, 1906.

ETABLISSEMENTS DE MM. SCHNEIDER & CIE. Nevers, 1900.

MATERIEL AUTOMOBILE. N. p., 1909.

ALBUM DES FERS ET ACIERS. 1895.

MATERIEL ELECTRIQUE A COURANTS ALTERNATIFS. Alternateurs, 1909.

—— Dynamos Schneider, Type "E" 1909, Type "S" 1909.

—— Moteurs triphases. 1905.

—— Transformateurs. 1907.

PRINCIPALES INSTALLATIONS COMPORTANT DES DYNAMOS "SCHNEIDER" A COURANT CONTINU. Liste des references. 1905.

—— ——— Annexe No. 1. 1906-1907.

PRINCIPALES INSTALLATIONS COMPORTANT DU MATERIEL ELECTRIQUE A COURANTS ALTERNATIFS DE NOTRE DERNIER TYPE. Liste des references. 1906.

—— ——— Annexe No. 1. 1907.

TRAVAUX D'AMELIORATION DU PORT DU HAVRE. Paris, 1907.

TRADE CATALOGUES.

COMPAGNIE DES FORGES ET ACIERIES DE LA MARINE ET D'HOMECOURT, FRANCE.
Iron and steel parts for automobiles, for buildings, wheels, castings of all kinds, projectiles, guns, fire-arms. 75 pages.

SCHNEIDER & Co., Paris, France.

Products and machinery manufactured by Schneider & Co. 19 pages.

Automobile wheels manufactured. 9 pages.

Creusot and manganese steel used in railway construction. 9 pages.

MEMBERSHIP.

NEW MEMBERS.

The following list comprises the names of those persons elected as members who accepted election during the month of April, 1910:

Members.

John A. Agnew,	Kalgoorlie, W. Australia.
Harry M. Booth,	Denver, Colo.
Lowell H. Brown,	Catasaqua, Pa.
Frederick J. Brulé,	Tooele, Utah.
John E. Butler,	Stearns, Ky.
William R. Chedsey,	Moscow, Idaho.
Marco Chiapponi,	New York, N. Y.
Frederick G. Clapp,	Pittsburg, Pa.
James B. Cook,	Punxsutawney, Pa.
Carl F. Dietz,	Boston, Mass.
Byron E. Eldred,	New York, N. Y.
Thomas W. Graham,	Workington, Cumberland, England.
Charles Holding,	Collinsville, Ill.
Edwin O. Holter,	New York, N. Y.
Andrew M. Howat,	Los Angeles, Cal.
Dyke V. Keedy,	Boston, Mass.
David H. Ladd,	Wallaroo, S. Australia.
Stuart B. Marshall,	Dunbar, Pa.
Pomeroy C. Merrill,	Hibbing, Minn.
Everett B. Moore,	Fairmont, W. Va.
Frank G. Morris,	Sayreton, Ala.
Peter A. Newton,	S. Chicago, Ill.
Hugh D. Pallister,	Cleveland, Ohio.
Karl C. Parrish,	Des Moines, Iowa.
Joseph W. Roe,	New Haven, Conn.
Robert B. Stewart,	Toronto, Ontario, Can.
Whitman Symmes,	Virginia City, Nev.
Harry S. Thayer,	Colorado Springs, Colo.
William P. Wescott,	Jersey City, N. J.
Lewis A. Westcott,	Many Peaks, Queensland, Australia.
Charles S. Witherell,	Newark, N. J.

CANDIDATES FOR MEMBERSHIP.

The following persons have been proposed for election as members of the Institute during the month of April, 1910. Their names are published for the information of members and associates, from whom the Committee on Membership

Life Member.

Lynn Yantis Keady, Portland, Ore.

Members.

Fred Hansen,	Salt Lake City, Utah.
William Henry Hayes,	Moonta Mines, S. Australia.
Wallace G. Imhoff,	Woodlawn, Pa.
Arthur James Miller,	Helena, Mont.
Walter Cornelius Minsch,	Telluride, Colo.
Edwin Thompson Perkins,	Granby, Mo
Roswell Eustis Sampson,	Boston, Mass.
Roy Arthur Sulliger,	San José de Gracia, Sinaloa, Mex.
Thomas Thomson,	Tottenville, N. Y.
Thor Warner,	Haileybury, Ontario, Can.
Ralph W. Watson,	Salt Lake City, Utah.

Associate.

Cuthbert Hale Brailsford, Sheffield, England.

CHANGES OF ADDRESS OF MEMBERS.

The following changes of address of members have been received at the Secretary's office during the month of April, 1910. This list, together with the lists published in *Bulletin* Nos. 38, 39, and 40, therefore, supplements the annual list of members corrected to Jan. 1, 1910, and brings it up to the date of May 1, 1910. The names of members who have accepted election during the month (new members) are printed in *italics*.

ADAMS, ARTHUR K.....General Land Office, Little Rock, Ark.

ADAMS, RALPH E., Asst. Supt., Velardena Unit, American Smelters.

Securities Co., Velardena, Dur., Mexico.

ADAMS, WILLIAM H.....P. O. Box 200, Portland, Ore.

**Agnew, John A.*, Min. Engr., Care Bewick, Moreing & Co.,

Kalgoorlie, West Australia. '09.

BAIRD, HENRY J. B..... West Chester, Pa.

BELDEN, SANFORD B., Mgr., Min. Dept., Jeffrey Mfg. Co.....Columbus, Ohio.

BIRCH, STEPHEN.....165 Broadway, New York, N. Y.

- *Booth, Harry M., Expert Miner, U. S. Forest Service, Majestic Bldg.,
Denver, Colo. '10.
- BRADLEY, RICHARD J. H.....170 Broadway, New York, N. Y.
- *Brown, Lowell H., Iron Mining & Blast-Furnace Work,
Care Empire Steel & Iron Co., Catasauqua, Pa. '10.
- *BRULÉ, FREDERICK J., Civ. and Min. Engr., International Smelting
& Refining Co., Tooele, Utah. '10
- BROWNLEE, ARCHIBALD G., Mgr. Stanley Mines Co.....Idaho Springs, Colo.
- BURLINGAME, W. E.1736 Lawrence St., Denver, Colo.
- BURROWS, R. H.....Apartado 212, Chihuahua, Mexico.
- *Butler, John E., Supt. of Coal Mines.....Stearns, Ky. '10.
- CARSON, ARTHUR C.....Room 2027, 42 Broadway, New York, N. Y.
- *Chedsey, William R., Asso. Prof. of Min. Engr., University of Idaho,
Moscow, Idaho. '10.
- *Chiapponi, Marco, Min. Engr., Care Messmore Kendall,
27 William St., New York, N. Y. '10.
- *Clapp, Frederick G., Cons. Geol. Engr.....331 Fourth Ave., Pittsburg, Pa. '10.
- CLARK, V. V.....444 Henry Bldg., Seattle, Wash.
- COOK, EDWARD H.....Instructed to hold all mail.
- *Cook, James B., Supt., Berwind-White Coal Mining Co., Spirit Bldg.,
unxsutawney, Pa. '10.
- DEGAN, JOHN.....Las Cruces, N. M.
- DICKERSON, WINCHESTER.....P. O. Box 329, Helena, Mont.
- *Diets, Carl F., Cons. and Met. Engr.....6 Beacon St., Boston, Mass. '10.
- DOERR, ALBERT.....P. O. Box 48, Ocean Park, Cal.
- DONNEWALD, ALBERT H.....3709 Finney Ave., St. Louis, Mo.
- DRUMMOND, JOHN J.....Care Canada Iron Corp., Ltd., Montreal, Canada.
- DUDGEON, NORMAN.....5 Ca Curzon St., London, England.
- DUFFIELD, WILL W.....Harlan, Ky.
- *Eldred, Byron E., Prest., Commercial Research Co., 32 W. 40th St.,
New York, N. Y. '10.
- ELLIS, EDWIN E.....1515 Brown-Marc Bldg., Birmingham, Ala.
- FRANK, ALBERT.....Apartado 53, El Oro, Mex., Mexico.
- GAMBRILL, GEORGE T., JR.....P. O. Box 514, Ensley, Ala.
- GEE, EMERSON.....228 W. 2d St., Los Angeles, Cal.
- GORMLY, SAMUEL J.....Care T. A. Gormly, Mt. Vernon, Iowa.
- *Graham, Thomas W., Mgr., Iron and Steel Works, Mossbay House,
Workington, Cumberland, England. '10.
- GUERNSEY, RAIMUND T.....1508 North American Bldg., Philadelphia, Pa.
- HAGUE, WILLIAM.....22 William St., New York, N. Y.
- HARGRAVES, ERNEST P., Care The Stock Exchange Club,
Melbourne, Vic., Australia.
- HIRSCHBERG, MAX R.....Teller, Alaska.
- *Holding, Charles, Supt., St. Louis Smltg. & Refg. Co.....Collinsville, Ill. '10.
- *Holler, Edwin O., Lawyer.....40 Wall St., New York, N. Y. '10.
- HOOPER, EDWARD, Care Hooper, Speak & Fielding, 3 London Wall Bldg.,
London, E. C., England.
- *Howat, Andrew M., Min. Engr., 908 W. P. Story Bldg., Los Angeles, Cal. '10.
- HOWE, HENRY M.....Broad Brook Road, Bedford Hills, N. Y.
- HUDSON, ALBERT W.....Great Cobar, Ltd., Lithgow, N. S. W., Australia.
- HUTCHINS, ROBERT G., JR.....56 William St., New York, N. Y.
- JENKS, ARTHUR W.....2209 Shattuck Ave., Berkeley, Cal.

- KANE, DANIEL B.....70 P St., Salt Lake City, Utah.
**Keedy, Dyke V.*, Cons. Met.....6 Beacon St., Boston, Mass. '10.
 KINGSTON, CHARLES B., Cons. Engr., Rhodesia Gold Mining & Investment Co.,
 Ltd., P. O. Box 501, Bulawayo, Rhodesia. So. Africa.
**Ladd, David H.*, Met., Wallaroo & Moonta Mining & Smelting Co., Ltd.,
 Wallaroo, So. Australia. '10.
 LAKENAN, CORNELIUS B.....McGill, Nev.
 LANE, HENRY M.....10613 Greenlawn Ave., Cleveland, Ohio.
 LINNEY, WILLIAM H.....2805 W. Mission St., Spokane, Wash.
 LYLE, COL. DAVID A.....St. Davida, Delaware Co., Pa.
 LYMAN, ROBERT H.....Care American Club, Mexico City, Mexico.
 MCAULIFFE, EUGENE.....McCormick Bldg., Chicago, Ill.
 MCCLURE, DAVID, Care E. C. Hutchinson, 409 Montgomery St.,
 San Francisco, Cal.
 MCCORMICK, EDWARD.....Buhl, Minn.
 MACDONALD, JESSE J.....P. O. Box 115, Los Angeles, Cal.
**Marshall, Stuart B.*, Asst. Genl. Mgr., Dunbar Furnace Co.....Dunbar, Pa. '10.
 MATHER, HENRY A.....Instructed to hold all mail.
 MATHER, THOMAS W., Gold Coast Amalgamated Mines....Tarkwa, West Africa.
 MEIN, WILLIAM W.....Care Hyde Park Hotel, London, S. W., England.
**Merrill, Pomeroy C.*, Min. Engr., Meriden Iron Co.....Hibbing, Minn. '10.
**Moore, Everett B.*, Min. Engr., Chief Engr., West Va. Div.,
 Consolidated Coal Co., Fairmont, W. Va. '10.
 MOORE, REDICK R., Cons. Engr., Mexican-American Holding
 & Improvement Co., 20 Broad St., New York, N. Y.
 MOORE, ROY W.....Noria, Son., Mex.
**Morris, Frank G.*, Genl. Supt. of Coal Mines.....Sayreton, Ala. '10.
 MYERS, DESAIX B.....321 Story Bldg., Los Angeles, Cal.
 NAETHING, FOSTER.....Miami, Ariz.
**Newton, Peter A.*, Asst. Genl. Supt., Illinois Steel Co., South Chicago, Ill. '10.
 OXNAM, THOMAS H.....2211 Cambridge St., Los Angeles, Cal.
 PADDACK, LEWIS E.....1815½ E. 2d St., Duluth, Minn.
**Pallister, Hugh D.*, Instructor in Applied Mechanics, Case School of
 Applied Science, Cleveland, Ohio. '10.
**Parrish, Karl C.*, Min. Engr.....408 Flynn Bldg., Des Moines, Ia. '09
 PARSONS, CYRIL E., 61 York Mansions, Battersea Park, London, S. W., England.
 PHILLIPS, WALTER I.....Homestake Mining Co., Lead, S. D.
 PIERCE, TALBOT E.....Care Semet-Solvay Co., Cleveland, Ohio.
 PORTER, ROBERT S.....160 W. River St., Wilkes-Barre, Pa.
 PUTNAM, BENJAMIN R.....651 Howard St., San Francisco, Cal.
 RAHT, AUGUST.....P. O. Box 621, San Francisco, Cal.
 ROBERTSON, JAMES D.....917 Carleton Bldg., St. Louis, Mo.
**Roß, Joseph W.*, Asst. Prof. in Mech. Engr., Sheffield Scientific School,
 New Haven, Conn. '10.
 ROPES, LEVERETT S., Care Ropes & McIntire, 325 Power Block, Helena, Mont.
 SAXMAN, CHARLES W., JR.....415 Depot St., Latrobe, Pa.
 SCHOLZ, CARL.....325 La Salle Sta., 144 Van Buren St., Chicago, Ill.
 SCHRÖDER, HAROLD.....Lanark, Lane Cove Road, Gordon, N. S. W., Australia.
 SCOTT, WALTER M. H.....Care Smuggler Union Mining Co., Telluride, Colo.
 SPANGLER, HOWARD.....329 San Fernando Bldg., Los Angeles, Cal.
 STAFFORD, C. EDWARD.....Care Union League Club, Philadelphia, Pa.
**Stewart, Robert B.*, Demonstrator in Met., Univ. of Toronto, 175 McCaul St.,
 Toronto, Ont., Canada. '10.

SUTCLIFFE, JOHN.....	511 Bayne Ave., Bellevue, Pa.
*Symmes, Whitman, Mine Mgr.....	Virginia City, Nev. '10.
*Thayer, Harry S., Mgr.....	Gladstone Reduction Co., Silver Cliff, Colo. '10.
THORN, JOSEPH F.....	Round Mountain, Nev.
TORBERT, JAMES B., Min. Dept., Cerro de Pasco Mining Co.,	
	Cerro de Pasco, Peru, So. Amer.
TRACY, PAUL B., Min. Engr., Utah Copper Co.....	Salt Lake City, Utah.
VIVIAN, GEORGE G., North American Smelter & Mines Co., Boston Bldg.,	
	Denver, Colo.
WALKER, ELTON W., Supt., Mass Cons. Mining Co.....	Mass City, Mich.
WARDEN, BRUCE R., Care Anderson & Warden, 413 Granville St.,	
	Vancouver, B. C., Can.
WASTE, HARRY L., Mgr., Midas G. M. Co.....	Knob, Shasta Co., Cal.
WEAVER, ISAAC S.....	Manchester, N. Y.
WEPFER, G. W., Care Miami Copper Co., P. O. Box 100, Miami, Gila Co., Ariz.	
*Wescott, William P.....	38 Bentley Ave., Jersey City, N. J. '10.
*Westcott, Lewis A., Min. Engr., Many Peaks Mine, Many Peaks,	
	Queensland, Australia. '09.
WHITMAN, PHILIP R.....	449 Pine Ave., Long Beach, Cal.
WILSON, HARRY.....	31 Queen St., Melbourne, Vic., Australia.
*Witherell, Charles S., Supt., Copper Dept., Balbach S. & R. Co.,	
	Newark, N. J. '10.
WOMBLE, LLOYD A., Care Princess Estate G. M. Co., P. O. Box 112,	
	Rodepoorte, Transvaal, So. Africa.
WORTH, JOHN G.....	Instructed to hold all mail.
WRIGHT, WILLIAM Q.....	24 California St., San Francisco, Cal.
ZOCH, FRANK P.....	514 Wood St., Pittsburg, Pa.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address on Records, from which Mail has been Returned.
Alexander, George E.,	Sparta, Ore.
Badger, Harry S.,	Goldboro, N. S., Canada.
Bailey, Marc,	Fort Dearborn Bldg., Chicago, Ill.
Bartoccini, Astolfo,	214 E. 90th St., New York, N. Y.
Bassett, Thomas B.,	Cumpas, Sonora, Mexico.
Batchelder, Joseph F.,	54 1st St., Portland, Ore.
Beck, Edwin L.,	Jardine, Mont.
Bellam, Henry L.,	Reno, Nev.
Bouchelle, James F.,	22 Duncan Ave., Jersey City, N. J.
Brown, Frank H.,	Coppermount, Alaska.
Bunker, Charles E.,	Monica Mines Co., Kirkland, Ariz.
Calero, Jose,	Pachuca, Hgo., Mexico.
Campa, Jose,	Mexico City, Mexico.
Claudet, H. Hayman,	Roseland, B. C., Canada.
Clemens, Fred Le Roy,	Reno, Nev.
Cragoe, A. Spencer,	Vencedora, Mexico.
Daniel, Mark,	United Elkhorn Mines, Baker City, Ore.
Dickson, George H.,	Lethbridge, Alberta, Canada.
Dougherty, Clarence E.,	41 Wall St., New York, N. Y.
Downs, M. E.	25 Broad St., New York, N. Y.
Ekberg, Benjamin P.,	Johannesburg, Transvaal, So. Africa.

Field, Wilfrid B.,	Mexico City, Mexico.
Fitch, Frank,	Black Mt. Min. Co., Magdalena, Mexico.
Foster, Lewis E.,	Utah Copper Co., Garfield, Utah.
Gaines, Ambrose P.,	Dayton Coal & Iron Co., Dayton, Tenn.
Geppert, Richard M.,	Ray, Ariz.
Greenley, Louis A.,	Prairie City, Ore.
Hunt, Thatcher R.,	Iron Mt., via Keawick, Cal.
Jewett, Eliot C.,	2918 Morgan St., St. Louis, Mo.
Kow, Tong Sing,	Shanghai, China.
McCan, E. K.,	Braden Copper Co., Graneros, Chile, S. A.
McGregor, J. Murray,	3 Minanciho, Ushigome, Tokyo, Japan.
Mildon, Reginald B.,	Nacozari, Son., Mexico.
Moulton, Herbert G.,	Cobalt, Ont., Canada.
Muir, Thomas K.,	Portland, Ore.
Perkins, Walter G.,	McGill, Nev.
Piper, John W. H.,	Buenos Ayres, Argentine Rep., S. A.
Potter, J. A.,	41 W. 124th St., New York, N. Y.
Rhew, James W.,	Culican, Sinaloa, Mexico.
Ripley, G. Clinton,	Craft, Cal.
Sandifer, Harmer C.,	El Oro, Mexico.
Scott, Winfield G.,	Long Beach, Cal.
Skelding, Joseph F.,	Embreeville, Tenn.
Thomas, Richard A.,	43 Wall St., New York, N. Y.
Weddle, Joseph H.,	San Juancito, Honduras, C. A.
Wilson, Odell,	Shingle, Cal.
Wolfe, Burton L.,	Ely, Nev.
Yates, Edwin F.,	P. O. Box 25, Rawhide, Nev.
Young, William,	Kenora, Ont., Canada.

NECROLOGY.

The deaths of the following members have been reported to the Secretary's office during the month of April, 1910:

Date of Election.	Name.	Date of Decease.
1887.	*Frank R. Carpenter,	April 1, 1910.
1906.	*Thomas A. Irvin,	January 2, 1910.
1907.	*Alfred Kimber,	April 7, 1910.
1905.	*Pietro Redaelli,	April 10, 1910.
1900.	**Thomas F. Walsh,	April 8, 1910.

* Member.

** Life member.

Improvement in Cyanide Practice.

BY E. GYBBON SPILSBURY, NEW YORK, N. Y.

(Pittsburg Meeting, March, 1910.)

THE recovery of gold and silver from their ores by means of the cyanide process has been so successful in the last few years that any radical improvement would seem impossible; yet the appliance to which I wish to call attention in this paper is really a radical departure from the methods now in general use.

The most modern and approved of these, known as the all-sliming method, depends for its success on the grinding of the ore so fine that practically 90 per cent. of it will pass through a 200-mesh screen. The slimes thus produced are then agitated and aerated in tanks of various types.

The main object of this treatment is to insure such a thorough admixture of the pulp and solution that every particle of the ore is surrounded by a volume of solution sufficient to insure the dissolving of the whole of the gold- and silver-content. In addition, in order to expedite the action of the cyanide, and to oxidize such elements as would, if left in their active state, become cyanicides, air is blown in under pressure. In the Pachuca tank, this air is the active and sole means of agitation.

The chief objections to all the methods of agitation used heretofore are the expense of operating and maintaining the mechanical devices for keeping the pulp in suspension, and the length of time required to obtain a fairly complete extraction of the values. These objections are inherent to any method of agitation effecting a circulation of the pulp and the solution together, by giving the whole mass a circular movement, as in the low-tank system, or a vertical circulation, as in the Pachuca-tank system. In both methods, the particles of ore are kept traveling in the same direction as the solution, and with very little difference of speed; so that, while the whole mass is in

violent motion, the relative positions of the ore-particles to their surrounding medium of suspension change but very slowly, and consequently the length of time required for a given extraction is much greater than would be necessary if the movements of the solution and the pulp were not coincident.

The improvement here described is a purely mechanical one, devised to meet this requirement. It rests simply on the discovery of a method of manufacturing a diaphragm of silica sponge, which, while strong enough to support heavy weights, is so evenly porous throughout that air can be passed through it with practically little resistance, and in which, nevertheless, the pores are so minute that no solid matter, however finely divided, can pass through or even into it.

In practice, this diaphragm is placed in the tank as a false bottom, resting on light channel-iron bars, 4 in. above the real bottom. The plates are either 12 by 12 or 12 by 20 in. in size, and are secured to the channel-iron supports, along the lines of intersection, by 0.25-in. carriage-bolts. When the plates are all laid, oakum is driven into the joints, which are then made completely tight by pouring in liquid cement.

This simple operation completes the whole installation. The charge is now run into the tank, and air is admitted from below, under a pressure of from 2 to 6 lb. only, depending on the depth of the charge. Immediately the whole charge becomes a seething mass of uniform but gentle agitation, in which every particle of ore is in constant motion, as is shown in Fig. 1.

No pressure is exerted on any of the air-particles after they have passed through the pores of the diaphragm. They simply levitate up through the mass by reason of their lower specific gravity. No distinct streams or lines of agitation are perceptible to the eye, but the charge shows a very distinct increase of volume, amounting to more than a foot of height in a 6-ft. tank; and the surface becomes covered with a coating of foam or air-bubbles, the thickness of which depends on the volume of air blown through the diaphragm. The full capacity of the sponge varies from 5 to 5.5 cu. ft. of air per minute per square foot of area at 1 lb. pressure.

Under these conditions the action of the cyanide is very rapid and intense. In 80 per cent. of the runs made, an extrac-

tion of over 50 per cent. of the combined gold- and silver-values has been obtained within the first hour of agitation; and while, in experimental work, our treatment is usually carried on for 12 hr., 6 hr. will probably be found to be the economical period in general practice.

It is found that the consumption of cyanide per ton of ore treated under this method is much less than in either the Pachuca or the mechanically-agitated tanks. This, I believe, is due chiefly to the briefer exposure of the cyanide to the oxidizing effect of the air, but also to the circumstance that we are able to treat effectively a much thicker pulp than the other methods of agitation will permit. With a proportion of 1.5 of solution to 1 of ore, we can obtain the quickest extraction; but, for facility of charging and discharging tanks, we generally make the mixture 2 to 1.

The accompanying records of work done with this porous diaphragm, on a commercial scale, in one of the large mills of the Guanajuato Development Co., show what remarkable extractions are obtained by this method.

One of the important questions we have had to study in the use of this material was, whether the pores of the sponge would not sooner or later become filled and choked by the very finest particles of ore, thus impairing the efficiency of the plates.

All our experience hitherto goes to prove that no such stoppage need be feared. The pores are so minute and so irregular in shape that apparently no solid matter can find entrance. In treating certain classes of ore we do find that, after a certain number of hours, the air-pressure begins to increase, by reason of a closing of the surface-pores of the diaphragm; but examination under the microscope has shown that this is due to a gradual deposit of lime carbonate on the surface of the plates, formed at the moment of contact of the air with the lime in solution. The removal of this coating, however, offers no difficulty. It can be done, between charges, either by sweeping the surface with a wire broom or by washing it with a weak solution of hydrochloric acid. In either case, the complete removal of the deposit takes place instantaneously, and the air-pressure drops to the normal.

The credit for the successful application of this porous medium to the cyanide process is due to J. E. Porter, of Syracuse,

N. Y., who, having acquired the material for an entirely different purpose, conceived at once its possibilities in the cyanide-field, and, by a long series of careful experiments, developed the many advantages of its present adaptation to that field.

Besides the employment of this silica sponge in the treatment-tanks, its usefulness has been demonstrated in the filtering of the solutions, and as a clarifier. Several types of silica-sponge filters are now building, of which probably the simplest consists of a table, from 25 to 30 ft. long and 8 ft. wide, the top of which is constructed of this porous material, under which is an air-tight pan, connected with an exhaust-pump. The pulp being run over the table, the solution is drawn through, leaving a dry cake of the desired thickness. Wash-water is then flowed over this cake, and it is washed in the usual manner. When the cake is finally dried, the table is tilted to a vertical position, and the cake is blown off by air-pressure. The mineral sponge always contains a certain amount of moisture, which causes a film of water to exude when the air-pressure is turned on; and this film, acting as a lubricant, aids the cake to free itself, so that the separation is immediate.

This filter has a capacity of from 40 to 50 tons of dry pulp per day. The resulting cake contains less than 23 per cent. of moisture when discharged. The simplicity of construction of this filter, its indestructible filtering-medium, and the absence of the innumerable valves and fittings required by all filters of the leaf-type, will recommend it strongly to mill men generally. I think it will increase the saving of values wherever it is introduced.

Another form of filter is being developed by the Just Process Company, using the silica sponge on the sides of a wheel, as illustrated in Fig. 2. The filter-wheel revolves slowly in a tank containing the pulp, the speed of travel being determined by the porosity of the cake to be formed. The formation of the cake takes place on the lower half of the wheel in submersion, the upper half of the wheel being used for drying the cake. The solution is withdrawn by vacuum through the hub of the wheel. In this case no attempt is made to wash the cake on the filter; instead of this, however, the cake is peeled off, as shown, by a knife on each side, at the end of its travel, and drops down into a cylinder containing rotary beaters re-

volving at a high speed and reducing the cake again to the consistency of pulp with a minimum amount of wash-water. In practice the product from this repulping-cylinder would pass to a second wheel and eventually to a third wheel for thorough washing. The filtering-operation is therefore continuous, and the cake as finally discharged is drier than that produced by any other method. The amount of solution extracted in the first operation is more than 85 per cent., leaving only 15 per cent. of moisture to be replaced by subsequent washing.



FIG. 1.—SURFACE OF A TANK, 12 FT. DEEP, WITH A SILICA-SPONGE FALSE BOTTOM, SHOWING AGITATION OF THE CHARGE.

An interesting laboratory-method for the rapid preparation of samples of cyanide-slimes, devised by Mr. Porter, consists in the use of a small hollow cylinder of the silica sponge, 4 in. in diameter by 4 in. in length, closed top and bottom by iron plates. Passing through the top plate is a pipe, which can be attached to any vacuum-line in the mill. The sample of pulp, taken in the usual way, is put into a galvanized-iron receptacle, and the porous cylinder is immersed in it. The vacuum being applied, the water is drawn out through the cylinder, around which a cake forms. When sufficient pulp has thus been solidified, the cylinder is removed to a second bucket and wash-water is drawn through until all the dissolved values have been removed. The cake is then removed with a spatula and dried.

In this way any number of samples can be rapidly prepared, and the long process of washing and decanting in the usual manner is entirely avoided. The resulting sample is also more

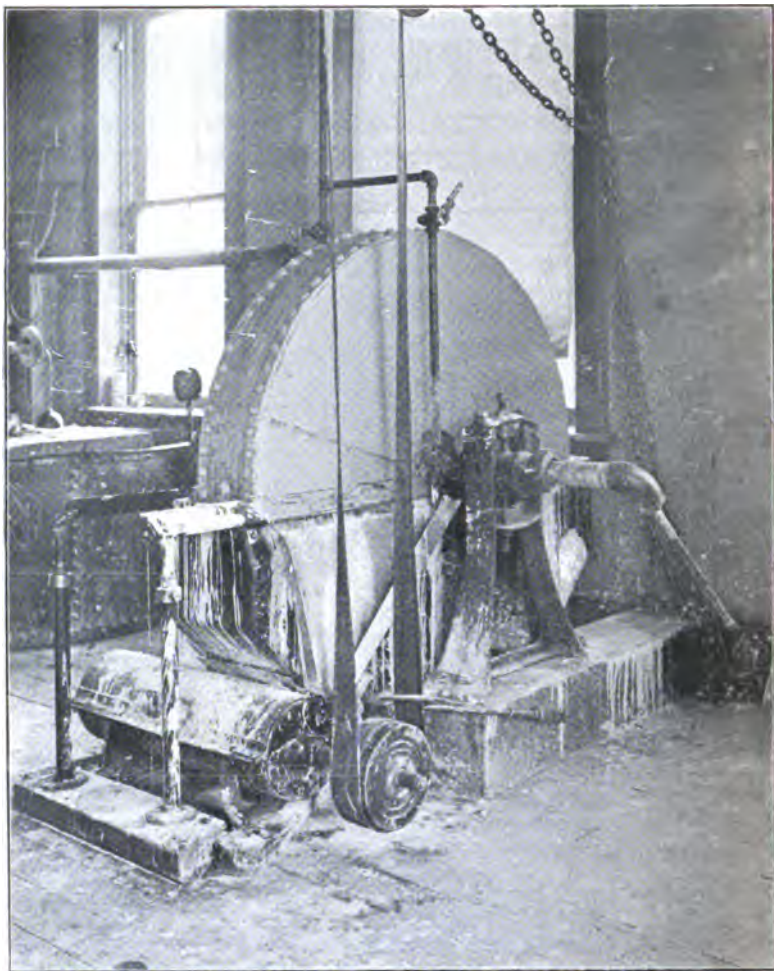


FIG. 2.—ROTARY SILICA-SPONGE FILTER.

thoroughly representative of the tank-charge than a sample prepared with the present crude way of washing.

Another application of this silica sponge may be found in the saving of the flue-dust of smelting-operations. Experiments along this line have not yet gone far enough to warrant the publication of detailed plans and results; but it is expected

that they will permit the proposal, at an early day, of a method replacing the present "bag-house" system for collecting all the solid particles from flue-gases of every description. This material, composed of nearly pure silica, having a very high fusion-point, and invulnerable to liquid acids or acid vapors, possesses in these respects indisputable advantages over the flannel bags now used.

APPENDIX.

EXPERIMENTAL TESTS MADE WITH THE POROUS DIAPHRAGM AT THE SAN MATIAS MILL, GUANAJUATO, MEXICO, IN NOVEMBER AND DECEMBER, 1909.

These tables give weights in tons of 2,000 lb. avoirdupois, and values in Mexican money at \$1.33 per gram, or \$41.34 per ounce, for gold, and \$0.033 per gram, or \$1.02 per ounce, for silver.

Test No. 3, November 5 and 6; 12 hours; 2.671 tons "Bolanitos" mine-ore. Screen-analysis: on 100-mesh, 2; on 200-mesh, 10; and through 200-mesh, 88 per cent. Fresh solution, 5.97 tons. Consumption of cyanide, 232 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.		
	Hr.	Deg. F.		KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
				Per Cent.	Kg.	Grams Per Ton.	Grams Per Ton.		Per Cent.	Per Cent.	Per Cent.
Heads.	0	63	3	0.39	0.644	2.17	126	\$7.04			
2	2	63	3	0.39	0.960	0.25	83	3.07	88.4	34.2	56.4
3	4	63	4	0.39	0.896	0.17	66	2.42	92.2	47.6	65.7
4	6	63	4	0.39	0.890	0.08	51	1.79	96.4	59.6	74.5
5	8	63	4.5	0.385	0.868	0.17	47	1.77	92.2	62.7	74.9
6	12	63	5	0.385	0.842	0.08	29	1.06	96.4	78.1	85.5

Test No. 4, November 8 and 9; 8 hours; 2.197 tons "El Refugio" dump- and mine-ore. Screen-analysis: on 100-mesh, 3; on 200-mesh, 12; through 200-mesh, 85 per cent. Fresh solution, 4.906 tons. Consumption of cyanide, 228 grams per ton of ore.

Sample No.	Agitation.		Temperature.	Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.		
	Hr.	Deg. F.			KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
					Per Cent.	Kg.	Grams Per Ton.	Grams Per Ton.		Per Cent.	Per Cent.	Per Cent.
Heads.	0	63	4		0.31	0.87	1.83	108	\$6.00			
	0.5	63	4		0.305	0.87						
2	1	68	4		0.305	0.84	0.33	77	2.98			50.2
3	2	68	4		0.305	0.81	0.17	63	2.80			61.7
4	4	63	5		0.300	0.78	0.25	50	1.98			67.0
5	6	62	6		0.300	1.12	0.25	38	1.58			73.7
6	8	61	6		0.300	1.04	0.17	32	1.28			78.7

Test No. 5, November 11 and 12; 22 hours; 2.77 tons "El Refugio" mine-ore. Screen-analysis: on 100-mesh, 2; on 200-mesh, 11; through 200-mesh, 87 per cent. Fresh solution, 5.9 tons. Consumption of cyanide, 426 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.		
	Hr.	Deg.		KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
		F.	Lb.								
Heads.	—	88	5	0.280	0.70	1.83	106	\$6.00			
2	1	88	5	0.270	0.70	0.83	92.7	8.48	87.8	8.5	42.0
3	2	89	5	0.270	0.75	0.17	72	2.60	90.8	33.4	56.6
4	4	89	5	0.270	1.00	0.08	62	2.15	95.7	42.6	67.5
5	8	88	5	0.330	0.85	0.08	48	1.68	95.7	55.6	72
6	16	72	6	0.320	0.80	0.08	22	0.82	95.7	79.7	86.4
7	22	89	6	0.320	0.84	0.08	22	0.82	95.7	79.7	86.4

Test No. 6, November 13 and 14; 12 hours; 1.88 tons "Santa Clara" mine-ore. Screen-analysis: on 100-mesh, 3; on 200-mesh, 10; through 200-mesh, 87 per cent. Fresh solution, 5.64 tons. Consumption of cyanide, 450 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.		
	Hr.	Deg.		KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
		F.									
Heads.	0	81	6	0.30	0.95	8.00	118	\$14.58			
2	1	89	6	0.30	0.98	0.17	57	2.10	97.9	51.7	85.6
3	2	95	6	0.30	0.92	0.08	85	1.25	99	69.9	91.4
4	4	94	6	0.295	0.96	0.08	28	1.02	99	76.3	93
5	6	90	6	0.295	0.96	0.08	23	0.86	99	80.6	94.1
6	8	87	6	0.295	0.94	0.08	21	0.79	99	82.8	94.6
7	12	88	6	0.420	0.92	0.08	18	0.69	99	84.8	95.3

Test No. 7, November 15 and 16; 12 hours; 2.16 tons "Puerto Rico" oxidized surface-ore. Screen-analysis: on 100-mesh, 2; on 200-mesh, 9; through 200-mesh, 89 per cent. Fresh solution, 4.384 tons. Consumption of cyanide, 234 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.		
	Hr.	Deg.		KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
		F.									
Heads.	—	77	6	0.39	0.89	1.67	265	\$10.96			
2	2	89	6	0.38	0.89	0.17	127	4.41	89.8	52.0	59.0
3	4	90	6	0.38	0.78	0.08	40	1.42	93.2	84.9	87.0
4	6	89	6	0.38	0.816	0.08	32	1.16	93.2	87.9	89.4
5	8	86	7	0.38	0.80	Tr.	22	0.72	99	91.7	93.4
6	10	84	7	0.38	0.80	Tr.	23	0.76	99	91.3	93.0
7	12	80	7	0.38	0.78	Tr.	18	0.59	99	98.2	94.6

Test No. 8, November 16 and 17; 12 hours; 2.723 tons "Puerto Rico" ore. Screen-analysis: on 100-mesh, 3; on 200-mesh, 12; through 200-mesh, 85 per cent. Fresh solution, 6.562 tons. Consumption of cyanide, 234 grams per ton of ore.

Sample No.	Agitation.		Temperature.	Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.			
	Hr.	Deg. F.			Lb.	KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
Heads.	0	79	6	0.37	0.84	2.50	268	\$12.00					
2	2	86	7	0.37	0.94	1.00	188	7.97	60	80.2	35.3		
3	4	91	7	0.37	0.85	0.88	148	5.82	86	43.8	55.7		
4	6	88	7	0.36	0.87	0.17	86	1.42	98.2	86.8	88.1		
5	8	87	7	0.36	0.84	0.08	85	1.25	96.8	86.7	89.6		
6	10	82	7	0.36	0.84	0.08	83	1.19	96.8	87.5	90.2		
7	12	78	7	0.36	0.87	0.08	28	0.91	96.8	89.4	92.4		

Test No. 9, November 18 and 19; 12 hours; 1.825 tons "El Refugio" oxidized ore. Screen-analysis: on 100-mesh, 3; on 200-mesh, 10; through 200-mesh, 87 per cent. Fresh solution, 5.717 tons. Consumption of cyanide, 297 grams per ton of ore.

Sample No.	Agitation.		Temperature.	Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.			
	Hr.	Deg. F.			Lb.	KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
						Per Cent.	Kg.	Grams Per Ton.	Grams Per Ton.		Per Cent.	Per Cent.	Per Cent.
Heads.	0	64	8	0.28	1.12	3.88	112	\$8.78					
2	2	76	4	0.27	1.12	0.50	136	5.14	87				
3	4	86	5	0.27	0.96	0.17	79	2.84	99				
4	6	86	5	0.32	0.96	0.06	36	1.28	99	2.90	67.6		
5	8	86	6	0.32	0.96	0.06	33	1.19	99	70.5	86.4		
6	10	80	7	0.32	0.96	0.06	26	0.96	99	76.8	89		
7	12	78	7	0.32	0.96	0.06	21	0.79	99	81.2	91		

Test No. 10, November 19 and 20; 12 hours; 2.378 tons "Pinguico" mill-ore. Screen-analysis: on 100-mesh, 2; on 200-mesh, 10; through 200-mesh, 88 per cent. Solution, 6.444 tons. Consumption of cyanide, 542 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.			Assays.			Extractions.			
	Hr.	Deg. F.		Lb.	KCN.		CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
					Per Cent.	Kg.								Grams Per Ton.	Grams Per Ton.
Heads.	0	68	4	0.34	1.04		7.33	864	\$38.35				
2	0			0.34	1.04		2.33	848	14.42	68.2	60.3	62.6	
3	2	71	5	0.34	1.00		0.83	188	6.48	95.5	78.8	88.1	
4	4	77	6	0.33	1.00		0.25	192	6.66	96.6	77.7	82.6	
5	6	80	7	0.33	1.00		0.06	55	1.91	99	93.6	95	
6	8	80	7	0.38	0.98		0.06	38	1.35	99	95.6	96.5	
7	10	80	7	0.32	0.94		0.06	29	1.06	99	96.6	97.2	
8	12	78	8	0.32	0.94		0.08	28	0.86	99	97.3	97.7	

Test No. 11, November 22; 12 hours; 3.16 tons "Pinguico" mill-ore. Screen-analysis: on 100-mesh, 2; on 200-mesh, 9; through 200-mesh, 89 per cent. Solution, 9.23 tons. Consumption of cyanide, 441 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.			
	Hr.	Deg. F.		Lb.	Per Cent.	Kg.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
Heads.	0	65	5	0.35	0.92	7.33	864	\$38.26	72.8	61.7	64.6 by Con.	
2	0	65	5	0.35	0.92	2.00	851	13.58	95.5	85.7		
3	2	69	5	0.35	0.92	0.33	124	4.53	95.5	85.7		
3+	2	Spec. from bottom of tank.				0.33	124	4.58	95.5	85.7		
4	4	72	5	0.35	0.88	0.25	75	2.80	96.5	91.3		
5	6	70	6	0.34	0.88	0.17	49	1.85	97.7	94.2		
6	8	67	6	0.84	0.86	0.17	37	1.45	97.7	95.7		
7	10	67	7	0.84	0.84	0.08	33	1.26	99	96.2		
8	12	65	7	0.84	0.84	0.17	25	1.04	97.7	97.2		

Test No. 12, November 23; 12 hours; 2.11 tons "Peregrina" mill-run. Screen-analysis: on 100-mesh, 2; on 200-mesh, 13; through 200-mesh, 85 per cent. Solution, 5.71 tons. Consumption of cyanide, 406 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.			
	Hr.	Deg. F.		Lb.	KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
					Per Cent.	Kg.							Grams Per Ton.	Grams Per Ton.
Heads.	0			0.24	0.98	7.00	126	\$11.27				
2	0	68	6	0.24	0.92	2.67	164	8.47	61.9			
3	2	68	7	0.85	0.89	0.42	69	2.83	94	46	74.9	
4	4	72	7	0.35	0.88	0.42	50	2.21	94	61	80.4	
5	6	71	7	0.35	0.84	0.17	21	0.92	97.6	83.4	91.9	
6	8	69	7	0.35	0.86	0.17	22	0.95	97.6	82.6	91.6	
7	10	69	8	0.35	0.84	0.17	20	0.89	97.6	83	92.3	
8	12	62	8	0.35	0.82	0.17	21	0.92	97.6	83.4	91.9	

Test No. 13, November 24; 12 hours; 2.986 tons "Peregrina" mill-run. Screen-analysis: on 100-mesh, 2; on 200-mesh, 12; through 200-mesh, 86 per cent. Solution, 6.09 tons. Consumption of cyanide, 408 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.		
	Hr.	Deg. F.		KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
Heads.	0	67	5	Per Cent.	Kg.	Grams Per Ton.	Grams Per Ton.		Per Cent.	Per Cent.	Per Cent.
2	2	72	7	0.37	0.90	7.00	126	\$11.27	92.9	61	79.3
3	4	72	7	0.37	0.86	0.33	28	1.36	95.3	77.8	88.0
4	6	70	7	0.37	0.86	0.33	20	1.10	95.3	84.2	90.2
5	8	68	7	0.365	0.86	0.33	19	1.07	95.3	85	90.5
6	10	65	8	0.365	0.82	0.17	15	0.72	97.6	88.1	93.7
7	12	65	8	0.365	0.78	0.17	13	0.66	97.6	89.7	94.2

Test No. 14, November 25; 14 hours; 1.61 tons "Peregrina" mill-ore. Screen-analysis: on 100-mesh, 2; on 200-mesh, 10; through 200-mesh, 88 per cent. Solution, 4.358 tons. Consumption of cyanide, 271 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.		
	Hr.	Temperature.		KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
		Deg. F.									
Heads.			Lb.	Per Cent.	Kg.	Grams Per Ton.	Grams Per Ton.		Per Cent.	Per Cent.	Per Cent.
2	0	66	5	0.24	0.61	6.5	169	\$14.22	89.7	67.5	81
3	2	68	5	0.24	1.00	0.67	55	2.70	95	85.8	91.4
4	4	78	5	0.86	0.66	0.83	24	1.22	96	92.8	95.4
5	6	77	5	0.86	0.66	0.17	13	0.65	97.4	91.2	95
6	8	74	5	0.86	0.66	0.17	15	0.72	97.4	91.2	91.4
7	10	70	5	0.86	0.66	0.17	13	0.65	96.2	92.9	95
8	12	67	5	0.86	0.66	0.25	12	0.72	97.4	98.6	96
	14	64	7	0.86	0.84	0.17	11	0.58			

Test No. 15, November 27; 12 hours; 1.75 tons "La Luz" mine- and dump-ore. Screen-analysis: on 100-mesh, 2; on 200-mesh, 10; through 200-mesh, 88 per cent. Solution, 5.55 tons. Consumption of cyanide, 317 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.		
	Hr.	Temperature.		KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
		Deg. F.									
Heads.			Lb.	Per Cent.	Kg.	Grams Per Ton.	Grams Per Ton.		Per Cent.	Per Cent.	Per Cent.
2	0	70	5	0.21	1.00	8.33	142	\$9.21	90	66.2	78.3
3	2	70	5.5	0.37	0.98	0.33	48	2.01	92.5	66.9	79.6
4	4	68	6.5	0.37	0.98	0.25	47	1.88	94.3	71.2	83
5	6	68	8	0.37	0.98	0.17	41	1.57	94.3	88.9	89.7
6	8	68	8	0.37	0.98	0.17	24	0.95	94.3	85.2	90.2
7	10	67	5	0.37	0.98	0.17	21	0.91	94.3	87.4	91.2
	12	67	5	0.37	0.98	0.17	18	0.81			

Test No. 16, November 29; 12 hours; 1.625 tons "La Luz" mine- and dump-ore. Screen-analysis: on 100-mesh, 2; on 200-mesh, 10; through 200-mesh, 88 per cent. Solution, 5.29 tons.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.		
	Hr.	Temperature.		KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
		Deg. F.									
Heads.			Lb.	Per Cent.	Kg.	Grams Per Ton.	Grams Per Ton.		Per Cent.	Per Cent.	Per Cent.
2	1	65	5	0.24	1.06	3.33	142	\$9.21	30		14.5
3	2	65	5	0.36	0.90	2.33	145	7.88	87.4	60.9	73.9
4	4	65	8	0.355	0.98	0.42	56	2.41	94.9	72.5	88.7
5	6	64	8	0.355	0.86	0.17	39	1.50	94.9	73.3	84.5
6	8	64	8	0.355	0.86	0.08	26	0.93	97.6	81.7	85.8
7	10	68	8	0.355	0.84	0.08	19	0.73	97.6	86.8	92.1
8	12	62	8	0.355	0.80	0.08	24	0.90	97.6	88.2	90.3

Test No. 21, December 5; 12 hours; 1.41 tons "Guanajuato mixture." Screen-analysis: on 100-mesh, 2; on 200-mesh, 12; through 200-mesh, 86 per cent. Solution, 4.244 tons. Consumption of cyanide, 1,200 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.			
	Hr.	Deg. F.		Lb.	Per Cent.	Kg.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
Heads.	0	64	3	0.145	0.68	Grams Per Ton.	Grams Per Ton.		Per Cent.	Per Cent.	Per Cent.	
2	After concentration.					8.42	294	\$14.24				
3	2	63	4	0.28	0.62	1.83	203	9.12	46.5	31.00	36.00	
4	4	63	5	0.28	0.52	0.67	108	4.45	80.4	63.8	68.8	
5	6	63	5	0.27	0.48	0.42	67	2.77	87.7	77.2	80.6	
6	8	62	5	0.27	0.44	0.17	27	1.11	95.1	90.8	92.2	
7	10	62	5	0.27	0.36	0.17	31	1.24	95.1	89.5	91.3	
8	12	62	6	0.26	0.34	0.17	25	1.04	95.1	91.6	92.7	
							25	1.04	95.1	91.6	92.7	

Test No. 22, December 6; 12 hours; 2.677 tons "Guanajuato mixture." Screen-analysis: on 100-mesh, —; on 200 mesh, —; through 200-mesh, 84 per cent. Solution, 6.367 tons. Consumption of cyanide, 714 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.		
	Hr.	Deg. F.		KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
Heads.	0	66	4	Per Cent.	Kg.	Grams Per Ton.	Grams Per Ton.		Per Cent.	Per Cent.	Per Cent.
2	2	65	7	0.275	0.96	3.42	294	\$14.24			
3	4	65	7	0.275	0.96	0.83	149	7.12	75.7	34.0	50.0
4	6	65	7	0.275	0.94	0.83	86	8.27	90.8	70.8	77.1
5	8	65	7	0.275	0.96	0.25	78	2.90	92.7	74.2	79.6
6	10	64	8	0.27	0.96	0.17	72	2.61	95.0	75.6	81.6
7	12	64	8	0.27	0.98	0.17	68	2.46	95.0	76.9	82.7
				0.27	0.98	0.17	66	2.40	95.0	77.6	83.2

Test No. 24, December 10; 22 hours; 3.878 tons "La Tula" ore, from La Luz district. Screen-analysis: on 100-mesh, 4; on 200 mesh, 12; through 200-mesh, 84 per cent. Solution, 6.327 tons. Consumption of cyanide, 978 grams per ton of ore.

Sample No.	Agitation.		Air-Pressure.	Titrations Per Ton of Solution.		Assays.			Extractions.		
	Hr.	Deg. F.		KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
Heads.	0	60	2	Per Cent.	Kg.	Grams Per Ton.	Grams Per Ton.		Per Cent.	Per Cent.	Per Cent.
2	1	60		0.335	1.00	21.28	1,710	\$84.73			
3	2	60	3	0.335	1.09	4.5	1,026	43.82	64.8	40.00	48.3
4	4	60	3	0.305	1.00	1.83	679	36.54	78.9	45.9	56.9
5	6	60	4	0.300	1.00	1.67	498	24.84	91.4	60.3	70.7
6	8	60	4	0.300	1.00	1.33	401	18.65	92.2	71.1	78.0
7	10	60	4	0.35	0.98	1.00	258	15.00	93.8	76.6	82.3
8	12	60	5	0.35	0.96	1.17	281	9.67	95.3	85.1	88.6
9	14	59	5	0.34	0.96	1.00	203	9.17	94.6	86.5	89.2
10	16	59	5	0.34	0.98	1.00	198	8.03	95.3	88.2	90.5
11	18	59	5	0.33	0.98	1.00	198	7.86	95.3	88.5	90.7
12	20	59	6	0.33	0.98	0.83	184	7.40	95.3	89.7	91.2
13	22	58	6	0.33	0.98	1.00	197	7.60	96.1	88.5	91.0
							165	6.87	95.3	90.4	91.9

Test No. 25, December 11 ; 16 hours ; 1.909 tons "La Tula" ore. Screen-analysis : on 100-mesh, 4 ; on 200-mesh, 13 ; through 200-mesh, 83 per cent. Solution, 395 tons. Consumption of cyanide, 800 grams per ton of ore.

Sample No.	Agitation.			Titrations Per Ton of Solution.		Assays.			Extractions.		
	Hr.	Deg. F.	Lb.	KCN.	CaO.	Gold.	Silver.	Value (Mex.)	Gold.	Silver.	Values.
				Per Cent.	Kg.	Grams Per Ton.	Grams Per Ton.		Per Cent.	Per Cent.	Per Cent.
Heads.	0	59	2	0.88	1.00	14.07	368	\$30.85			
2	2	59	3	0.87	1.00	2.08	408	16.06	82.5		
3	4	59	4	0.86	0.98	1.17	271	10.50	61.7	26.4	47.9
4	6	59	5	0.86	0.98	0.67	187	6.06	95.6	49.2	80.4
5	8	58	5	0.85	0.98	0.58	155	5.88	95.9	57.9	80.9
6	10	58	5	0.85	0.98	0.58	131	5.09	95.9	64.4	83.5
7	12	58	6	0.85	0.96	0.58	121	4.76	95.9	67.2	84.6
8	14	58	6	0.84	0.96	0.58	118	4.66	95.9	67.9	84.9
9	16	57	6	0.84	0.96	0.50	116	4.48	96.5	70.4	85.5

Electric Mine-Hoists.*

BY D. B. BUSHMORE AND K. A. PAULY, SCHENECTADY, N. Y.

(Pittsburg Meeting, March, 1910.)

I. INTRODUCTION.

OF primary importance in mine-installations is the hoist, which has a very direct bearing on the successful operation of a mine. Conditions vary greatly with different mines, and especially in different localities. Such factors as depth, incline, the number of levels, permissible or desirable speeds, conditions of ore, etc., are always more or less special in each case. Veins of ore are never exactly duplicated, and the nature of the ground through which shafts are sunk may considerably modify permissible values. As mining-laws are made by the different States, they necessarily vary somewhat, and, even when not fully observed, they introduce factors which qualify the conditions of hoisting men and ore. The amount of timbering required is often of importance as relating to hoisting-conditions. Methods of loading ore affect the time required, as also does the question of the use of cars or skips. Safety-precautions must be very carefully considered, and the number of men in each mine, the number of compartments, and often the method of removing water from the mine, must have careful consideration.

While a general discussion of the subject of hoisting is possible, most cases are entirely special, and can be considered only in connection with the peculiar conditions pertaining to that particular installation.

The cost of installation of the hoisting-plant may be an appreciable amount, while the cost of raising the ore may be but a small part of the total operating-charge. In many cases, however, the output of the mine is limited by the capacity of the hoist, and the latter thus becomes of the first importance.

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Where shafts have not been sunk to their final depths, the conditions of operation are of necessity constantly changing, and it is impossible to predetermine with exactness the precise conditions of operation which will be followed in practice.

1. *Power for Mines.*—Power is used for drilling, tramming, pumping, ventilating, hoisting, compressing air, crushing rock, and for many minor operations. In coal-mines, the washeries and breakers, and in metal-mines, the mills and concentrators, are ordinarily located in proximity to the shafts. The problem of lighting always exists.

Owing to the distances between different points of applications of power, not only the question of utilization, but also that of transmission, becomes of importance. Three forms of power—steam, compressed air, and electricity—are to be considered. Originally, of course, the power must come from coal or water-power.

2. *Choice of System.*—The choice of the best system of hoisting in any particular case is the result of considering carefully many different factors. Most important among these is the cost of operation and installation. In this regard the location of the power-house to insure the best and cheapest supply of fuel and water is of primary importance. It is highly desirable to group a large number of mines, so that they may be supplied from one power-station. As a rule, mining-shafts are not well situated as regards the supply of coal and water, so that it is usually necessary to transmit power for some distance, and this is best done by electricity. The problem then becomes one of the utilization of power, or the generation of electricity by means of steam-turbines or gas-engines. In metal-mining, fuel is usually expensive, and often but little water is available at the mines, so steam hoisting-engines are generally run non-condensing. Where the reverse is the case, it is in most cases cheaper to transmit electricity to the mines than to pump condensing-water there.

3. *Efficiency of Steam Plants.*—Steam hoisting-plants are known to be very inefficient, but the exact figures are usually difficult to obtain. With non-condensing engines and an extremely intermittent load on both engines and boilers, the economy necessarily is very poor. Steam-engines must be designed for starting-conditions, where they take steam under

full stroke, and this necessitates their running with an early cut-off when hoisting. With a number of plants close together, there is no way of returning power to the line or of smoothing the peaks of the load. It is impossible, when a steam-engine is used, to store power in retardation. There is also a limit to the depth at which steam-engines can be satisfactorily placed, and their installation in mines is thus very undesirable.

4. *Advantages of the Electric System.*—In many cases the electric system of hoisting has advantages which give it decided preference. The power-house may have the most favorable location—power may be taken from some existing transmission-system, or a water-power may be developed for the purpose. Power may be centrally generated at the highest efficiency, and distributed over a large area. Electricity is most easily applied to all work on both the surface and the interior of mines. One of its greatest advantages in practice is the ease of making extensions to the development. With one station and many individual loads, an overlapping of peaks occurs, and a consequent reduction in boiler- and generating-capacity is effected. The cost of installation and operation is much reduced, a much improved load-factor results and fewer operators are required.

For underground pumping and tramping, and where the hoists are located in the mine, electricity has every advantage. For use with electric hoists, safety-devices have been developed which prevent overwinding and which also limit the acceleration. Power can be returned to the system in braking and in lowering unbalanced, and a much higher fuel-economy can be obtained.

The use of hoists operated by compressed air has long been considered, and at present some installations are being made. With the usual features of such equipment, it is necessary to cool the air during compression and to reheat it before use. In general, serious questions would arise concerning the efficiency of any system using compressed air for hoisting. The efficiency of an electric hoisting-system is not open to question, and can be figured with exactness. There is no reason why advocates of compressed-air systems should not be required to give the same guarantees and to state positively just what efficiency they are sure of obtaining.

II. MOTOR CHARACTERISTICS.

Large electric mine-hoists are almost universally driven either by shunt-wound direct-current motors or polyphase induction-motors, the characteristics of which especially adapt them to meet the peculiar conditions imposed. While in many of their characteristics these two types of motor are similar, they differ widely in others, which are of more or less importance, depending upon special conditions of individual cases.

Fig. 1 gives the efficiencies, currents, and speeds of the direct-current shunt-motor at various loads for constant impressed voltage, and Fig. 2 gives similar curves for the induction-motor, to which is added the power-factor curve. By reference to these curves it will be seen that the free-running speed of each motor is limited, and that the variations in speed with changes in load are small; that each becomes a generator when driven above speed, and may therefore be used as a brake when lowering unbalanced loads, returning power to the supply-system; that the efficiencies of both when operating either as motor or generator are virtually the same for corresponding loads.

The speed of the shunt-motor for a given load may be varied between standstill and full speed either by changing the potential of the supply-system, or by inserting resistance in series with its armature. However, because of the inefficiency of this latter method of control, it is seldom, if ever, used in connection with large hoist-motors. The only practical method of obtaining a similar variation in the speed of an induction-motor is by changing the amount of resistance connected in its armature circuit. Fig. 3 shows the efficiencies of the shunt-motor at various speeds when exerting full-load torque, the variations in speed being obtained by voltage-control, and the efficiencies of the induction-motor being under similar conditions, except that in this case the variations in speed are obtained by armature rheostatic control. By reference to the curves it will be seen that for a given torque, the efficiency-curve of the shunt-motor at reduced speeds resembles that for the constant-speed motor at reduced loads, while the efficiency-curve of the induction-motor is a straight line between full-load efficiency and speed, and zero efficiency and speed. From this it follows that, for a given value of torque, the input to the shunt-motor at reduced

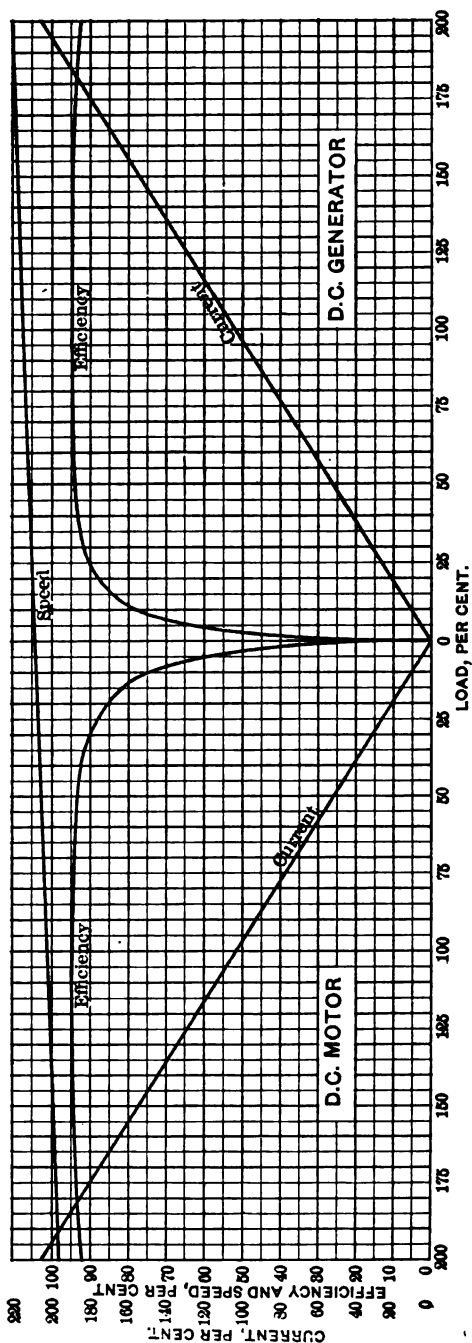


FIG. 1.—EFFICIENCY, CURRENT, AND SPEED-CURVES OF DIRECT-CURRENT SHUNT-MOTOR AT VARIOUS LOADS FOR CONSTANT IMPRESSED VOLTAGE.

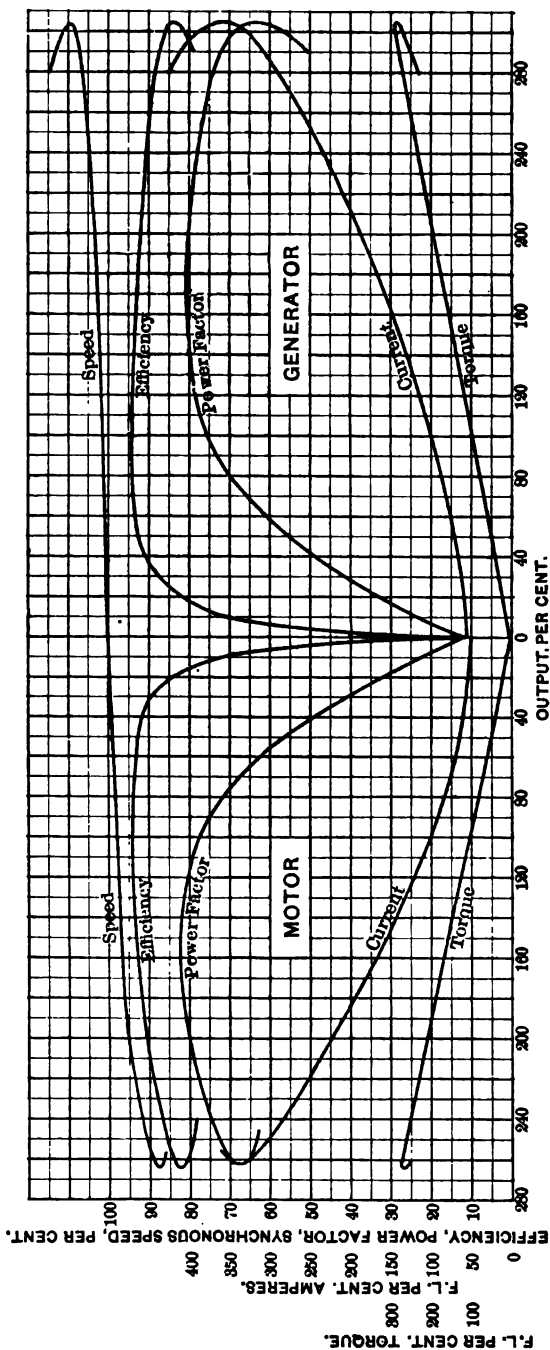


FIG. 2.—EFFICIENCY, CURRENT, SPEED, AND POWER-FACTOR-CURVES OF INDUCTION-MOTOR AT VARIOUS LOADS FOR CONSTANT IMPRESSED VOLTAGE.

speeds, except for very low speeds, is approximately proportional to the speed, while the input to the induction-motor is constant and independent of the speed. It will also be noted that the shunt-motor may be driven as a generator at reduced speeds, while the induction-motor can be made to generate only when driven above synchronous speed. Where the conditions are such that it is desirable to drive the hoist at reduced speeds for any considerable lengths of time, the efficiency of the induction-motor drive may be improved by using a motor designed for two speeds, or by using a concatenated set, but the advan-

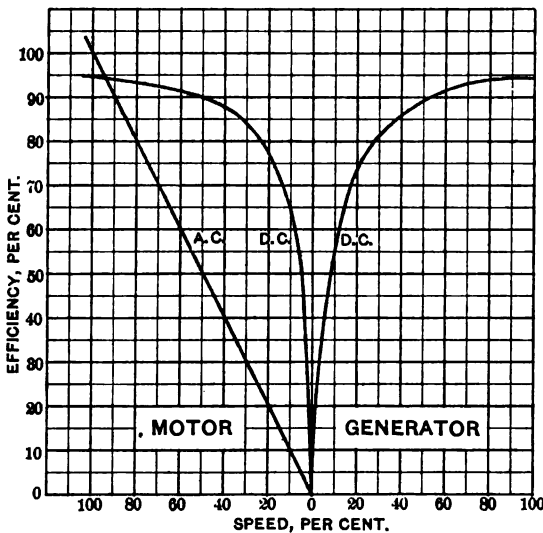


FIG. 3.—EFFICIENCY-CURVES OF SHUNT-MOTOR AT VARIOUS SPEEDS.

tages gained are seldom sufficient to off-set the increased first-cost and the necessary complication of the control.

The number of poles, and therefore the diameter, of an induction-motor is determined by its speed and the frequency of the supply-system, the number of poles varying inversely as the speed for a given frequency, while the frequency of the electromotive force generated in the armature of a direct-current motor is independent of the supply-system. While this is of little importance in the designing of motors of moderate speed for gearing, it permits of a better proportioning of the length and diameter of shunt-motors of very slow speed than is possible in the case of similar induction-motors for direct connection, especially where the frequency of the supply-system is 60 cycles.

As pointed out, the efficient speed-control of the shunt-motor is only obtained by varying the voltage of the supply-system, the usual method being to provide a generator for each motor and to vary the generated potential. As mine-shafts are usually scattered over a considerable area, and the conditions in close proximity to the shafts are not such as to permit of the economical generation of electric power, the central electric station is usually placed at a considerable distance from the hoists. The power is generated and transmitted to the mines as alternating current, and is then transformed at each shaft into direct current by motor-generator sets. The losses caused therein must be charged against the shunt-motor when comparing its efficiency with that of the induction-motor, which may be connected either directly or through highly-efficient static transformers with the alternating-current distributing-system. The torque and current for the two types of motor are approximately proportional within their operating-limits.

III. HOIST LOAD-DIAGRAMS.

Before discussing the various systems of electric hoisting it will be well to consider the nature of a mine-hoist load. Mine-hoists may be divided into six types, depending upon whether the rope is wound on a reel, a cylindrical drum, a conical drum, a cylindro-conical drum, Whiting drums, or carried over a Koepe disk, the choice of any particular type depending largely upon the depth of shaft, the maximum permissible hoisting-speed, the location of the hoist with respect to the shaft, the number of levels which are being worked simultaneously, and whether or not the shaft-conditions permit the use of a tail-rope.

The hoists are generally operated in balance; that is, the weight of the skip (or cage and car, as the case may be) carrying the ore is balanced by a similar empty skip, which is lowered in a second compartment simultaneously with the hoisting of the loaded skip in the first, the loaded skip being dumped at the top and the empty one loaded at the bottom, and the cycle then repeated. To permit of adjustment of the length of the ropes for hoisting from different levels, it is customary to use two reels or drums mounted on the same shaft, one being keyed to the shaft and the other being driven by it

through some form of clutch. The length of rope on the Koepe disk-hoist or the Whiting hoist cannot conveniently be adjusted for different levels except within very small limits.

For the purpose of comparing the load-diagrams of the different types, each hoist is assumed to lift 8,000 lb. of ore in a skip weighing 5,000 lb., from a vertical depth of 2,500 ft., at an average speed of 2,000 ft. per minute, allowing 20 sec. for acceleration and 15 sec. for retardation. The rope for the reel-hoist is assumed to be 0.5 by 5 in., weighing $4\frac{1}{2}$ lb. per foot, and that for the others $1\frac{3}{8}$ -in. round steel rope, weighing 3 lb. per foot.

1. *Reel-Hoist*.—As its name indicates, the reel-hoist consists of two large reels on which the rope supporting the skips is wound in a spiral, the distance between the flanges of the reels being approximately equal to the width of the flat rope used. The reel-hoist is generally used where it is necessary to place the hoist very close to the shaft. As the minimum diameter of the reel, usually from 5 to 8 ft., is limited, and as its maximum diameter is determined by the thickness and length of the rope, the depth from which hoisting may be done at a given average speed by reel-hoists is governed by the maximum permissible hoisting-speed.

Let us assume that the loaded skip is at the bottom of the shaft and that the empty skip is at the top. Then the length, L_a , of the ascending rope with the skip at any point in the shaft may be obtained from the equation

$$L_a = D - 2\pi a r_1 - \pi a^2 b,$$

and its moment, M , about the drum-shaft by

$$M_1 = (D - 2\pi a r_1 - \pi a^2 b) r n \cos \phi,$$

in which D = depth of shaft; b = thickness of the rope; n = the weight of the rope per foot; r_1 = the radius of the rope on the reel when the skip is at the bottom of the shaft; a = the number of turns of the reel in raising the skip from the bottom of the shaft to the point in question; $r = r_1 + ab$ = the radius of the rope on the reel after a turns; and ϕ = the angle which the shaft makes with the vertical.

The moment of the ascending load is obtained from the equation

$$M_1 = (W_1 + W_2) r \cos \phi,$$

where W_1 = the weight of the skip (or cage and car, as the case may be); and W_2 = the weight of the ore.

Plotting M_1 and M_2 against revolutions of the reel, we obtain curves M_1 and M_2 in Fig. 4.

The moment M_1' of the descending rope may be plotted from the values obtained for the ascending rope, by simply assuming the center of co-ordinates in Fig. 4 transferred from the left to the right side of the curves, turn No. 10 of the descending load corresponding to turn No. 81 of the ascending load, etc.

Similarly, the moment M_2' of the descending load may be obtained by substituting W_1' for $W_1 + W_2$ in the equation for M_2 , and plotting as directed for the descending rope.

Moments M_1' and M_2' are plotted below the reference-line, since their tendency to rotate the reel is opposed to that of M_1 and M_2 .

Denoting the moment of the total friction and windage by M_f , the resultant moment M_0 of the ascending ore-skip, rope, and friction, and the descending skip and rope, is expressed by $M_0 = M_1 + M_2 - M_1' - M_2' + M_f$, which is the moment of the force, or the torque which must be applied to the reel to raise the ore.

The moment M_f of the friction is extremely difficult to obtain, and varies considerably with local conditions, but it is usually assumed to be approximately 15 per cent. of the average value of $M + M_2 - M_1' - M_2'$.

During the period of acceleration, a force additional to that required to raise the load and overcome friction must be applied to the reel for accelerating the reels, ropes, etc. Assuming a uniform rate of acceleration, the moment M_a of the force necessary for accelerating the ascending load, rope, and one reel and clutch, may be determined from the equation.

$$M_a = \frac{\Sigma W S}{g t_a} p,$$

where ΣW = the sum of the weights of the skip, ore, rope, one reel and clutch, and sheave, reduced to a common radius

of gyration, p ; S = the speed at the end of the radius of gyration in feet per second at the end of acceleration; $g = 32.2$, and t_a the time of acceleration in seconds.

Similarly, the moment M'_1 of the force required for accelerating the descending skip, rope, etc., may be found from the equation

$$M'_1 = \frac{\Sigma W' S}{g t_a} p,$$

where $\Sigma W'$ = the sum of the weights of the descending skip, rope, reel, and sheave, reduced to the radius of gyration, p .

$$S = 2 \pi p R,$$

where R = the revolutions of the reel per second at full speed.

When the time allowed for making one complete trip is given, R may be found from the following equation

$$R = \frac{-r + \sqrt{r^2 + \frac{b D}{\pi}}}{b} \times \frac{1}{T - .5 (t_a + t_r)}$$

Where T = total time of lift in seconds (not including time for loading or dumping),

t_a = time for acceleration in seconds,

t_r = time for retardation in seconds.

At the end of the cycle all of the energy stored in the revolving parts of the hoist and its load is returned as the load is brought to rest. The moments M_1 and M'_1 of the retarding-forces may be found from the expressions for M_1 and M'_1 , respectively, substituting for ΣW and $\Sigma W'$ the corresponding weights at the beginning of retardation.

Throughout the cycle there is a gradual increase in the speed of the ascending ore-skip and unwound rope, and a similar decrease in the speed of the descending skip and unwound rope, but the accelerating- and retarding-forces are small and their moments may be neglected.

The resultant moments M_A and M_R during the periods of acceleration and retardation respectively are expressed by the equations

$$M_A = M_1 + M_2 + M_3 + M_4' + M_F - M_1' - M_2';$$

$$M_R = M_1 + M_2 + M_F - M_1' - M_2' - M_4 - M_0'.$$

M_A, M_0, M_R of Fig. 4 is the resultant moment-diagram for balanced hoisting under the conditions assumed.

While hoists are generally operated in balance, it is frequently necessary to run them unbalanced for short periods while repairs are being made. The moment-diagram M_A, M_0, M_R for unbalanced hoisting is obtained from the equations

$$M_A = \frac{M_F}{2} + M_1 + M_2 + M_3;$$

$$M_0 = \frac{M_F}{2} + M_1 + M_2;$$

$$M_R = \frac{M_F}{2} + M_1 + M_2 - M_4.$$

The speed of the ascending or descending skips in feet per minute at any point may be obtained from the equation

$$V = 120 \pi r R.$$

2. *Cylindrical-Drum Hoists.*—The cylindrical-drum hoist is the type almost universally used for comparatively shallow shafts, and very frequently for the deeper ones. It consists of two cylindrical drums, upon which the rope is wound in one or more layers, the diameters of the drums varying from 5 or 6 ft. to 25 feet.

The general equations for determining the several moments which make up the reel-moment diagram are made applicable to the cylindrical-drum hoist by simply making b equal to zero.

For the cylindrical drum,

$$R = \frac{D}{2 \pi r} \times \frac{1}{T - .5 (t_a + t_r)}.$$

The moment-diagrams for the cylindrical-drum hoist are shown in Fig. 5. The notches in the diagram are due to the increase in diameter of the drum with each layer of rope.

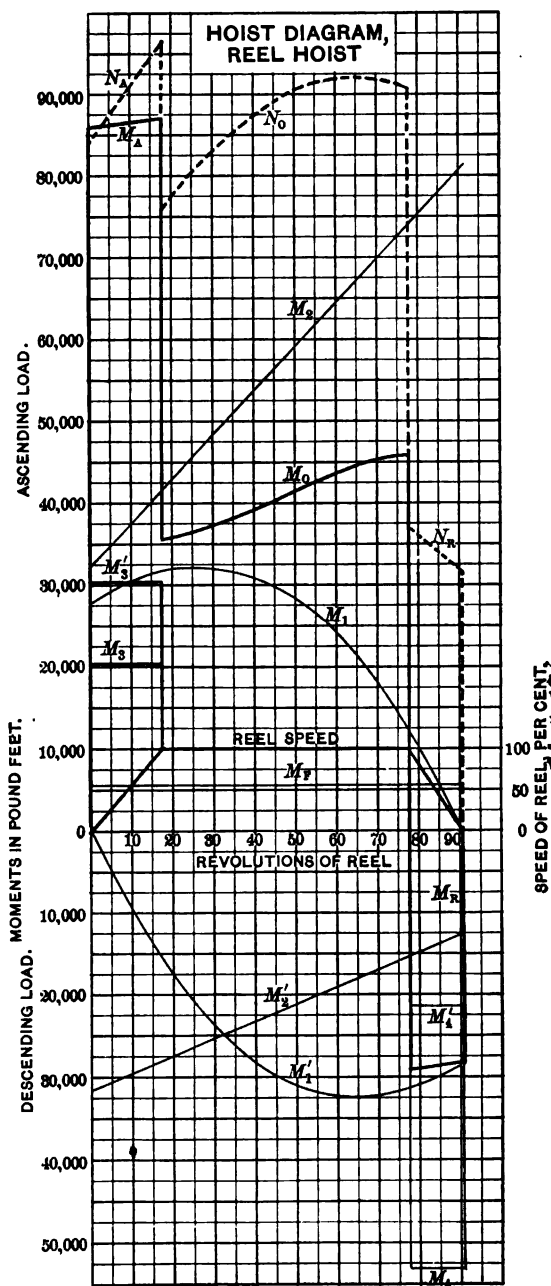


FIG. 4.—LOAD-DIAGRAM, REEL HOIST.

By reference to the figure, it will be seen that M_0 , the resultant moment of the ore-skips and ropes, is very large at the first part of the cycle and decreases very rapidly towards the end of the cycle, this being due to the influences of M_1 and M_1' , the moments of the rope. This difference in M_0 at the beginning and at the end of the cycle increases with the depth of the shaft, the weight of ore per trip remaining constant; or for the same depth of shaft with reductions in the weight of ore hoisted, M_0 often becoming partly zero or negative towards the end of the cycle. The harmful effect of this extreme variation in M_0 is two-fold. First, the engine must be larger than otherwise necessary, in order to start the hoist, and second, it operates at an inefficient cut-off at the end of the cycle. To reduce this variation in M_0 at the beginning and at the end of the cycle, the conical drum has been introduced.

3. *Conical-Drum Hoists*.—In the conical-drum hoists, the ropes are wound in single layers on two large cones, the rope being wound from the small to the large end of the cone. The method of determining the moment-diagrams is the same as for the reel-hoist, making b equal to the increase in the radius of the cone for one turn of the rope. By reference to Fig. 6, which shows the moment-diagrams for the conical-drum hoist, it will be noted that the unbalancing due to the rope in the shaft has been entirely compensated for; in fact, M_0 actually increases towards the end of the cycle. By varying the angle of the cone, M_0 may be made to increase or decrease towards the end of the cycle, or remain practically constant.

4. *Cylindro-conical Drum Hoist*.—The use of the conical drum, as was the case with the reel, is limited to comparatively shallow shafts. For depths below which the use of the conical drum is impracticable, it is necessary to compromise, using a drum which, as its name indicates, is a combination of cone and cylinder. The rope is wound from the small end of the cone over the conical part of the drum in a single layer; then on to the cylindrical portion in one or more layers, depending upon the length of the rope. The load-diagram is readily obtained by dividing the cycle into two parts, and treating the conical and cylindrical portions of the drum separately, determining the moments over the conical part as directed for the conical-drum hoist, and over the cylindrical portion as directed for the cylin-

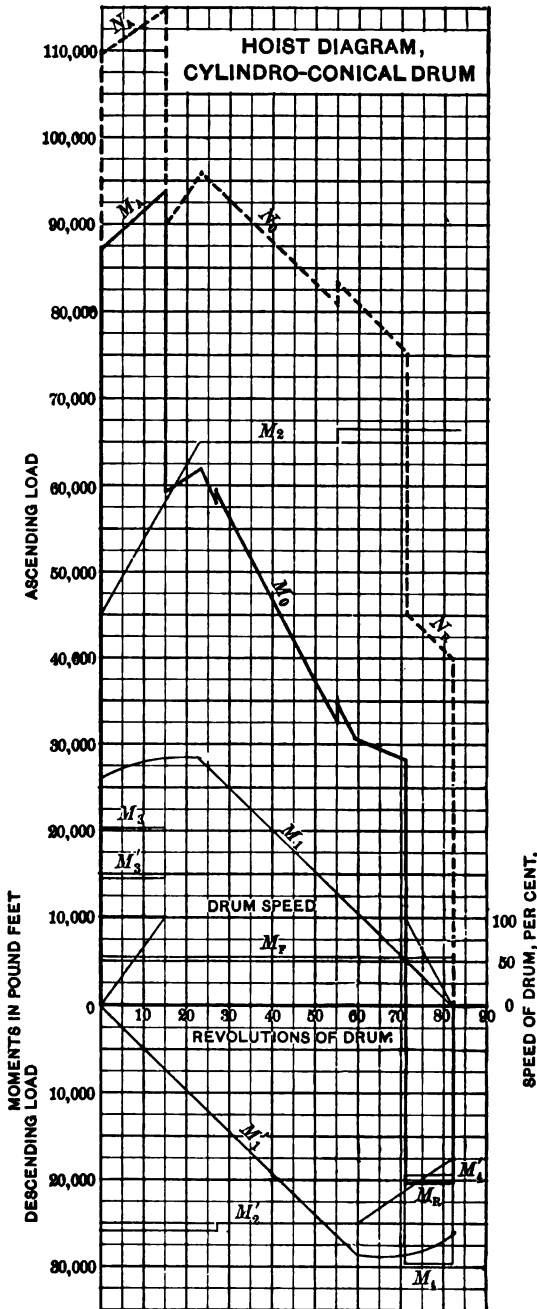


FIG. 7.—Load-Diagram, CYLINDRO-CONICAL DRUM HOIST.

sulting from the addition of a tail-rope to the cylindrical-drum hoist, which otherwise remains unchanged.

6. *Koepe Disk-Hoist*.—A type of hoist very common throughout Europe, but which has never been installed in America, is that known as the Koepe disk-hoist, which consists simply of a large grooved wheel over which the rope passes once, the friction between the disk and the rope being sufficient to move the cages or skips in the shaft. Hoists of this type are always operated in balance and a tail-rope is used with them. They are not well adapted for hoisting from several levels, because of the fixed position of the cages or skips, which can be changed only with difficulty to correspond with different levels. The moment-diagram of this type of hoist is similar to that of the cylindrical-drum hoist with a tail-rope, except that b_0 will be a horizontal line, the notches due to the different layers of rope on the drum not being present in the Koepe disk-hoist diagram.

7. *Whiting Hoist*.—In order to increase the arc of contact between the rope and the wheel, Mr. Whiting substituted two narrow drums for the Koepe disk, the drums being placed one directly in front of the other, and the rope being passed four or five times over both drums. For the purpose of taking up the stretch in the rope and making small adjustments of the cages, one side of the rope is carried back over a movable sheave mounted on a carriage resting on rails, the adjustments being made by changing the position of the carriage. Whiting hoists are always operated in balance and seldom, if ever, without a tail-rope. The moment-diagram is exactly similar to that of the Koepe disk-hoist.

The moment-diagrams may be transformed into horse-power-time diagrams by the use of the equation

$$\text{horse-power} = \frac{2 \pi M R}{550},$$

where M = the moment in pound-feet and R = revolutions of the drum per second.

The horse-power diagrams corresponding to the moment-diagrams of Figs. 4, 5, 6, and 7 are shown in Fig. 8, the curves for the balanced hoisting only being shown. Attention is called

to the difference in the heights of the peaks during acceleration, the magnitude of these peaks having an important influence

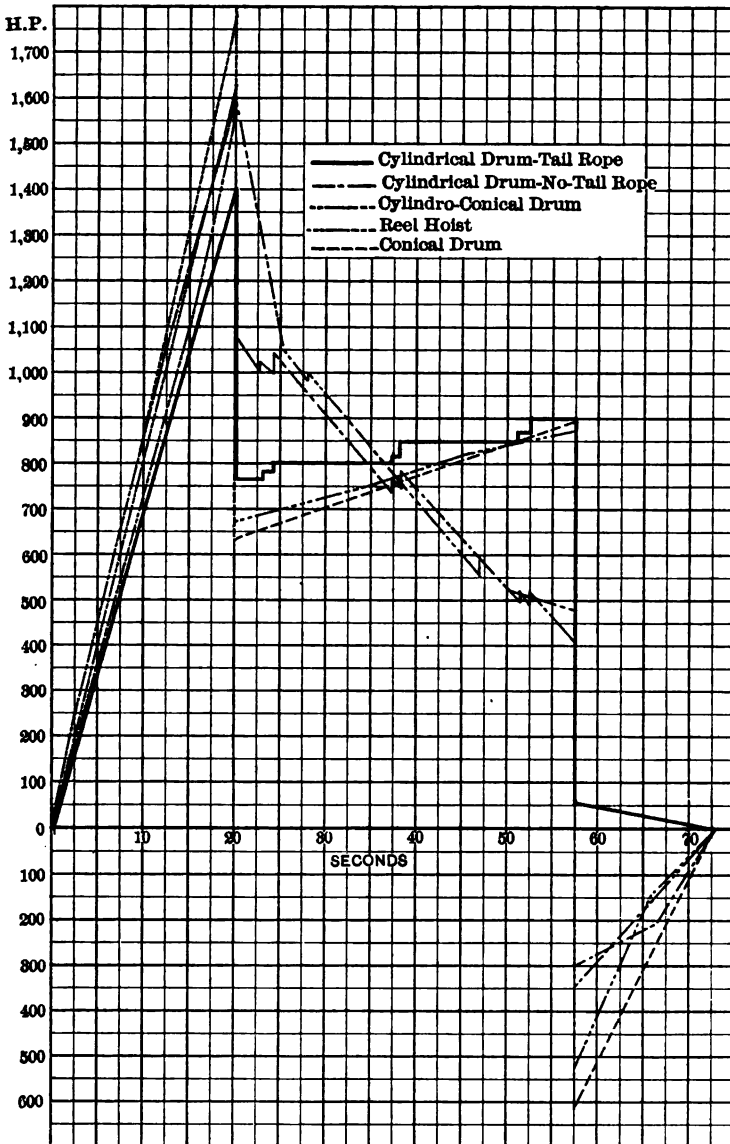


FIG. 8.—HORSE-POWER DIAGRAM FOR BALANCED HOISTING.

on the design of a motor for driving the hoist, its efficiency for the complete cycle, and the cost of power, if power is purchased.

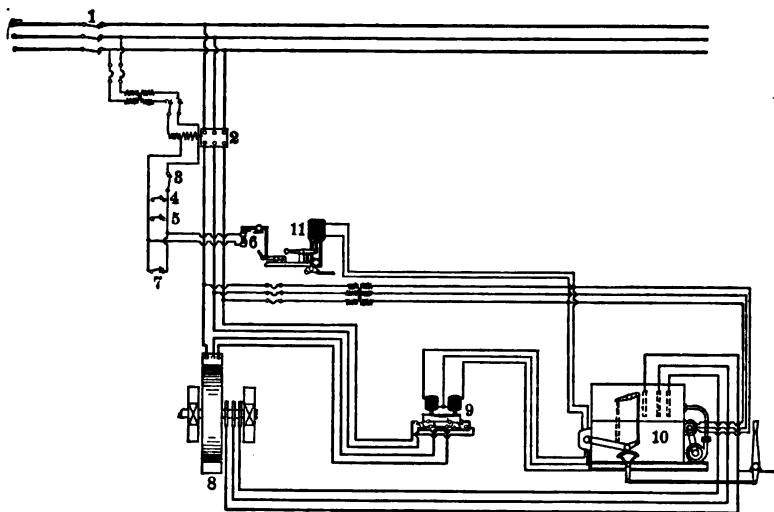
IV. SYSTEMS OF ELECTRIC HOISTING.

The early application of electric power to mine-hoisting was confined to small hoists, moving cars on inclines, or hoisting light loads vertically from comparatively short depths. The complete success of these early installations led to the use of electric motors for winding from greater depths, until to-day ore is hoisted by electric power from some of the deepest mines in the world. The use of electric motors for driving the hoists permits of the substitution of a large central electric generating-station, which operates at a comparatively high load-factor, and which is placed where the conditions are more favorable for the economical development of power than they are at the mines, in place of isolated steam-plants located at the shafts, where condensing-water is seldom available and where fuel is often expensive. The speed of the hoist-motor when lowering unbalanced loads is automatically limited to approximately the hoisting-speed. Safety-devices in the nature of limit-switches can readily be applied to prevent overwinding, and the acceleration of the hoist is made automatic; all of which tend to minimize the possibility of accident resulting from carelessness on the part of the operator. Not only is the speed limited when lowering unbalanced, but a large part of the energy, which with the steam-driven hoist is absorbed by the brakes, is returned to the electric supply-system, thereby improving the economy of operation and reducing the wear on the mechanical brakes.

Many systems of electric hoisting have been proposed, each with the view of meeting some peculiar condition, or eliminating some real or apparent objection in the others, but virtually all the installations are confined to four systems, shown in Figs. 9, 12, 15, and 20. To assist in the comparison of the several systems, the authors have assumed a hoisting-cycle, for both balanced and unbalanced operation, and have calculated the current and power taken by each system under the conditions assumed.

The first and simplest system is shown in Fig. 9, and consists of a polyphase induction-motor, direct connected or geared to the hoist-drum. The speed of the motor is controlled by a variable resistance in its rotor circuit, which, because of the magnitude of the currents involved, is usually some form of

water-rheostat. A common type of water-rheostat consists of a tank, usually of boiler-plate riveted together, and divided into two compartments: one the rheostat proper, and the other a cooling-tank. The electrolyte is pumped from the cooling-tank into the rheostat proper, entering at the bottom of the rheostat and flowing out over the top of an adjustable weir, back into the cooling-tank. The resistance in the rotor circuit is varied by changing the height of the electrolyte in the rheostat proper by means of the adjustable weir. The electrodes are usually thin iron plates hung on insulators, all phases



1, 2. Line switches. 3, 4, 5, 6, 7. Safety switches for preventing overwinding and stopping the hoist. 8. Hoist motor. 9. Reversing switch. 10. Liquid controller. 11. Automatic brake.

FIG. 9.—INDUCTION MOTOR SYSTEM.

being in the same compartment. At least one electrode per phase is of extra length, extending below the lowest level of the liquid, in order to prevent the rotor circuit from being opened. The most common form of electrolyte is a simple salt solution. The control of the rheostat is by means of a lever located on the operating-stand.

Figs. 10 and 11 give the current- and power-curves for one complete balanced and unbalanced cycle, respectively. Frequently the cage is moved a few feet only, to obtain a proper setting of the cage or skip. The power taken for such short movements is shown by the right-hand curves of Fig. 10. In

these curves, as well as in those which apply to the other systems, power delivered to the hoist is shown above the reference-line, and that returned by the hoist, below it.

By reference to the curves, it will be noted that the horsepower and current taken by the motor are constant during the period of acceleration; that the efficiency for this period is very low, approximately 45 per cent.; that no power is returned to the supply-system during the period of retardation; and that

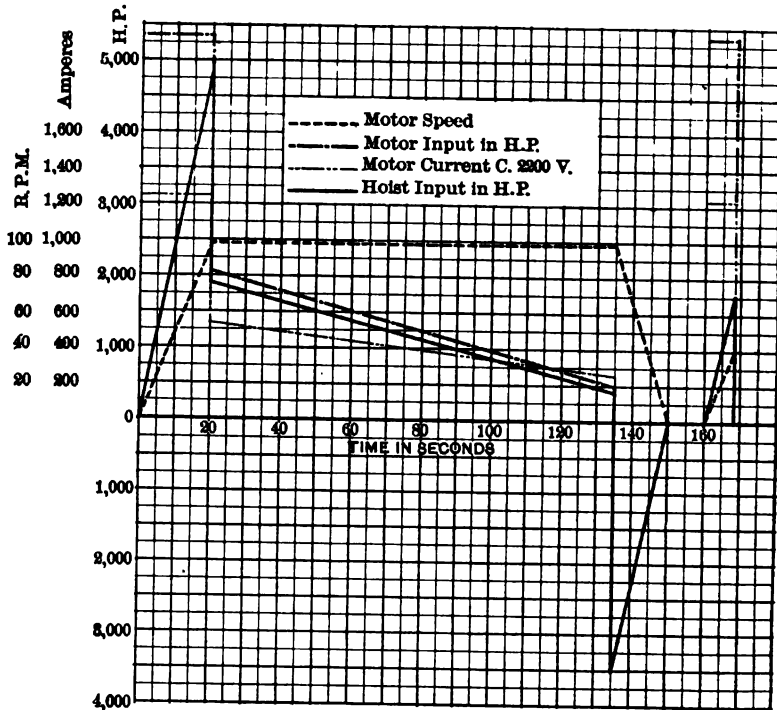


FIG. 10.—CURRENT- AND POWER-CURVES OF A BALANCED CYCLE OF THE SYSTEM SHOWN IN FIG. 9.

the power-consumption for small movements of the cage or skip is very large. On the other hand, the efficiency during the period when the hoist is running at full speed is high, approximately 90 per cent., and no power is consumed while the hoist is at rest.

The efficiency over the complete cycle obviously decreases rapidly with a decrease in the time during which the hoist is driven at full speed. It follows from this that when hoisting is

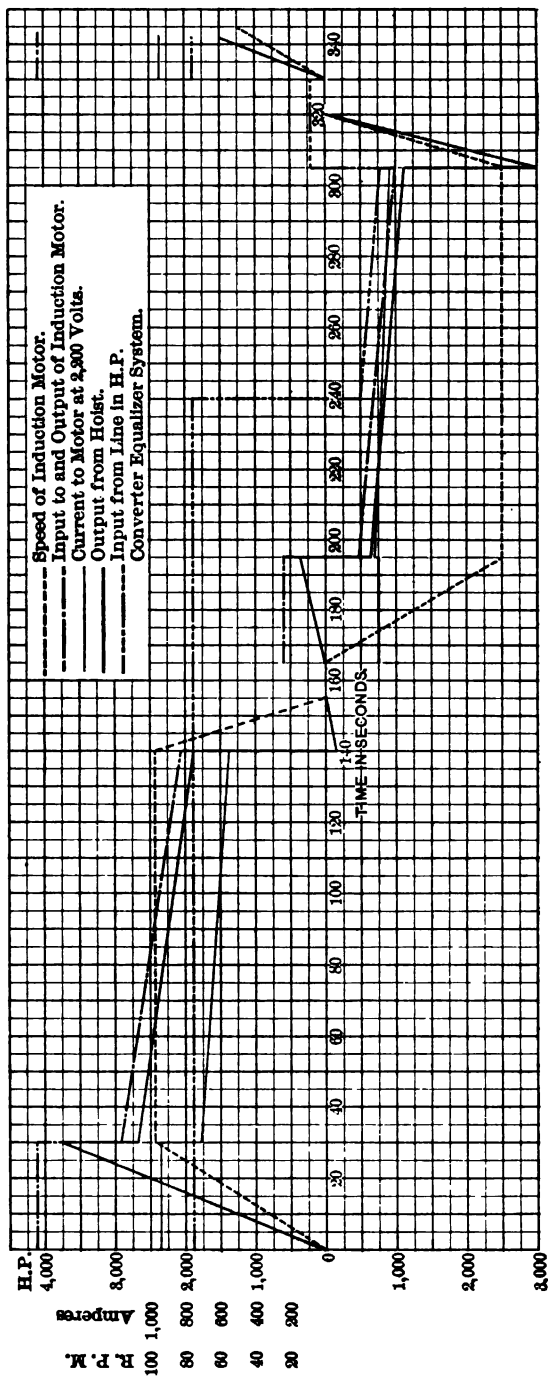
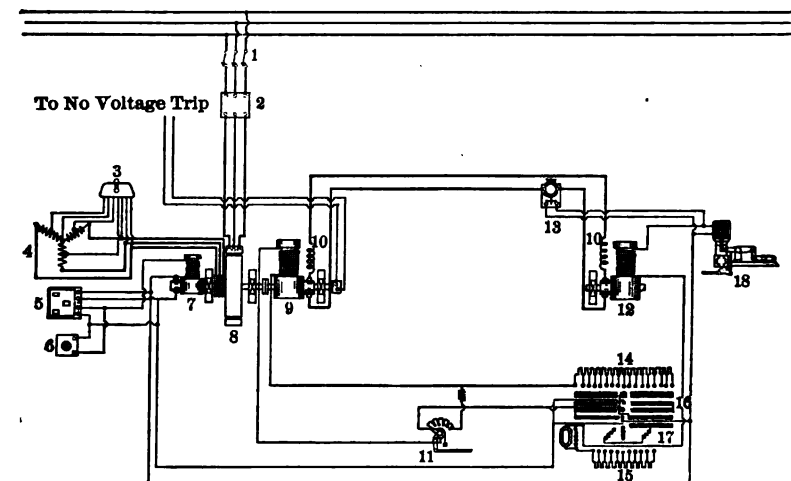


FIG. 11.—CURRENT- AND POWER-CURVES OF AN UNBALANCED CYCLE OF THE SYSTEM SHOWN IN FIG. 9.

to be done from several levels, the efficiency at the maximum depth alone cannot be used as a basis for comparing the hoist driven by the induction-motor with other systems. The efficiency of the cycle increases with an increased rate of acceleration, from which it follows that an induction-motor for hoisting should be designed for a high maximum output to permit of a rapid acceleration.

The power returned to the system when lowering the empty skip unbalanced is shown by the right-hand curves of Fig. 11.



1, 2. Line switches. 3, 4. Controller and resistance, induction motor. 5, 6. Tirrill regulator and rheostat for exciter. 7, 8, 9. Motor-generator set. 10. Commutating pole and compensating field winding. 11. Safety device. 12. Hoist motor. 13. Circuit breaker. 14, 15, 16, 17. Rheostat and controller for generator and hoist motor. 18. Automatic brake solenoid.

FIG. 12.—SYNCHRONOUS MOTOR-GENERATOR SYSTEM.

A comparison of the power taken by the motor in hoisting the loaded skip with that returned when it is lowered empty, shows that approximately 20 per cent. of the power taken for hoisting is returned in lowering.

The second system is that shown in Fig. 12. In this system the hoist is driven by a direct-current shunt-wound motor, receiving power from the alternating-current supply-system through a synchronous or induction-motor-generator set. The hoist-motor is controlled by varying the voltage of the generator, which is separately excited, one generator being used for each motor.

The power- and current-curves for the balanced and unbalanced cycle are shown in Figs. 13 and 14, respectively. These curves show that the power consumed during acceleration is much smaller than for the induction hoist-motor, the efficiency then being approximately 80 per cent., and that a considerable part of the energy stored in the revolving parts of the hoist is returned to the supply-system as the hoist is brought to rest. On the other hand, the efficiency when the hoist-motor is running at full speed is lower than that for the induction hoist-

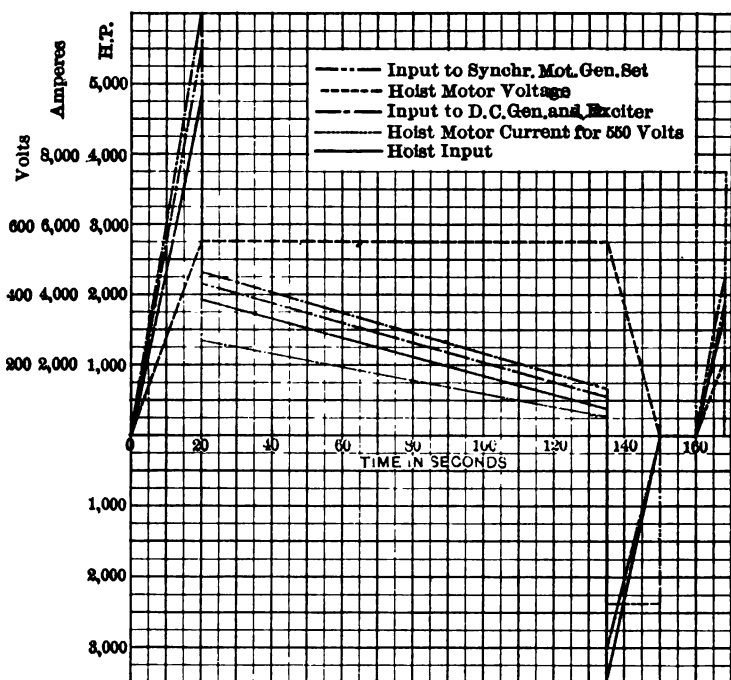


FIG. 13.—CURRENT- AND POWER-CURVES FOR A BALANCED CYCLE OF THE SYSTEM SHOWN IN FIG. 12.

motor, being approximately 82 per cent., and the losses of the motor-generator set when running light must be supplied during the time when the hoist is at rest. In view of the fact that a mine-hoist is idle 50 per cent. or more of the time under ordinary conditions, this is an item in the total power-consumption which cannot be neglected. It follows, from what has been stated, that the advantage of the direct-current hoist-motor over the induction hoist-motor in the efficiency through the complete cycle is greatest for short lifts, in which case the

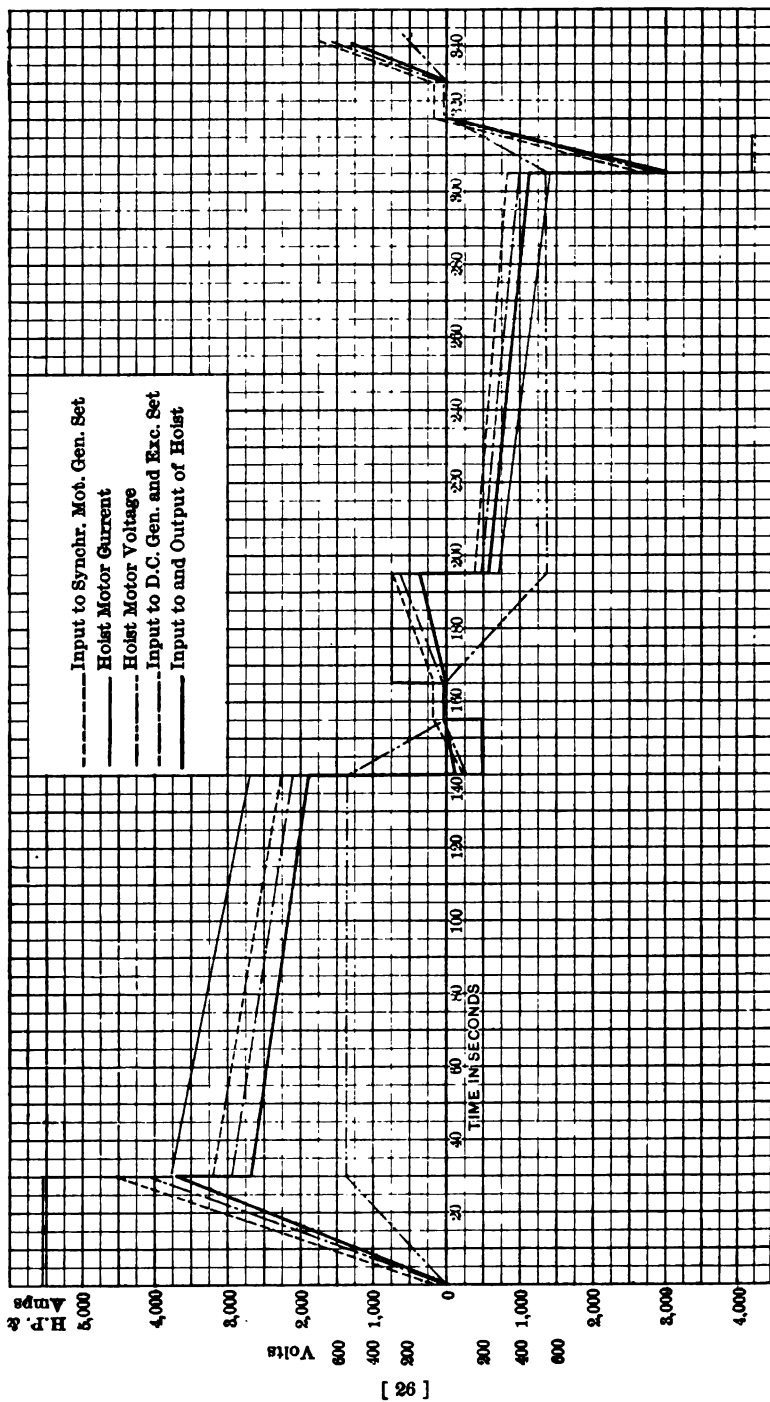


FIG. 14.—CURRENT- AND POWER-CURVES FOR AN UNBALANCED CYCLE OF THE SYSTEM SHOWN IN FIG. 12.

period of acceleration is a large percentage of the total cycle, and the time during which the hoist is idle is a minimum.

By reference to the curves of Fig. 14, it will be seen that approximately 80 per cent. of the power consumed in hoisting the ore unbalanced is returned to the system when the skip is lowered.

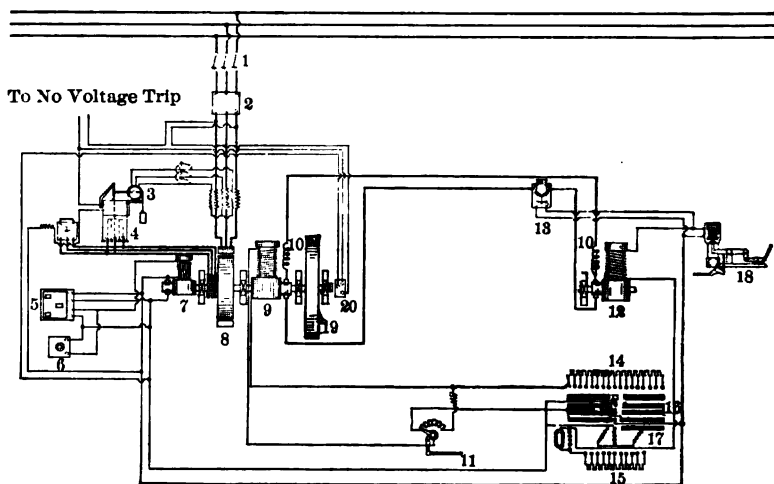
No definite rule can be laid down by which a choice can be made between the systems, each having advantages and disadvantages peculiar to itself which have a more or less important bearing on the choice, depending upon the special conditions of the individual problem. The first system has the advantages of low first-cost and simplicity, but is often at a disadvantage in respect to efficiency. On the other hand, the higher efficiency of the second system is frequently more than off-set by its increased first-cost and its greater cost of maintenance.

Both systems are open to the objection that the power drawn from the supply-system fluctuates between very wide limits during each cycle, generally reaching a maximum during acceleration, becoming negative during retardation for the second system, zero, or practically so, at the end of the cycle, and negative when lowering unbalanced for both systems. The effect of this wide fluctuation in the load during each cycle is to impair seriously the voltage-regulation of the supply-system unless its capacity is large as compared with the fluctuations, or unless the number of hoists driven from the same system is sufficient to produce a fairly-uniform load, which is seldom the case for a mine power-system. Also, if power is purchased, the price is usually made up of two components: one based on the total kilowatt-hours consumed, and the other on the maximum demand.

It therefore becomes necessary in most cases to provide some means whereby power may be taken from the supply-system and stored during the portion of the cycle when the demand for power is less than the average, and returned when the demand exceeds the average.

Fig. 15 shows such a system, the third, in which advantage is taken of the low first-cost and efficiency of the fly-wheel as a means for storing and returning large quantities of power for short intervals. This system is similar to the second, except

for the addition of a fly-wheel to the induction motor-generator set, and an automatic regulator for varying its speed. In its most common form, this regulator consists of a water-rheostat connected in series with the induction-motor armature. The resistance is varied by means of movable electrodes suspended from an arm mounted on the shaft of an induction-motor, which is connected in series, either directly or through series transformers, with the induction-motor of the fly-wheel set. The regulator-motor is so connected that its torque opposes the weight of the electrodes, which are partly counterbalanced to



1, 2. Line switches. 3, 4. Slip regulator. 5, 6. Tirrill regulator and rheostat. 7, 8, 9, 19. Fly-wheel motor-generator. 10. Commutating pole and compensating field winding. 11. Safety device. 12. Hoist motor. 13. Circuit breaker. 14, 15, 16, 17. Rheostat and controller of generator and hoist motor. 18. Automatic brake solenoid. 20. Speed limit device.

FIG. 15.—FLY-WHEEL MOTOR-GENERATOR SYSTEM.

reduce the size of the regulator-motor to a minimum, and permit of an adjustment of the regulator for different values of line-current. When the line-current exceeds the value for which the regulator is adjusted, the torque of the motor overbalances the weight of the electrodes, lifting them and inserting resistance in the armature circuit of the induction-motor. This causes it to slow down, and allows the fly-wheel to assist in driving the generator during the peak-loads. The sensitiveness of this regulator varies with the line-current, but within the range of ordinary operation the line-current may readily

be held within 5 per cent. either side of the mean, provided the hoisting is done at a uniform rate and the regulator is adjusted for the average load. In actual practice the regulator must be set for the maximum condition, so that under ordinary conditions of hoisting the current is limited rather than maintained constant.

The weight of the fly-wheel is determined from the hoist-diagram by correcting it for the losses in the hoist-motor and generator. Let Fig. 16 be such a diagram, and let a , b represent the average for the cycle. Then the energy represented by the portion of the diagram above the average-line

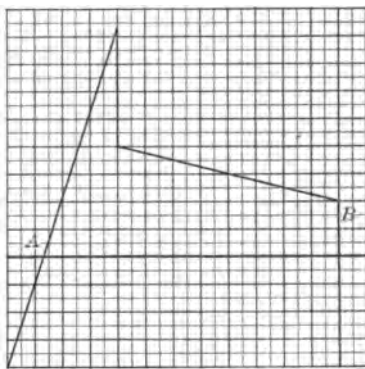


FIG. 16.—HOIST-DIAGRAM SHOWING AVERAGE FOR THE CYCLE.

must be delivered by the fly-wheel during the peak-load. The weight of the fly-wheel may be obtained from the equation

$$W = \frac{2 g E}{Y_0^2 - Y_1^2},$$

where W = effective weight of wheel; Y_0 = the velocity of the wheel at a ; Y_1 = the velocity of the wheel at b ; and E = the energy in foot-pounds to be delivered by the wheel. It is the usual practice to make Y_0 approximately 300 ft. per second, in which case the actual weight of the wheel is approximately equal to 1.33 W .

A convenient method of obtaining the effective weight of a wheel is shown in Fig. 17. Having decided upon the radius of gyration in feet, and the speed in revolutions per minute, the weight of a wheel required to deliver any number of horse-

so on as indicated by the dotted line, which assumes a wheel having a radius of gyration of 4 ft., running at 600 rev. per minute and delivering 25,000 h-p-sec. with a 20-per cent. drop in speed. The effective weight of the wheel is approximately 39,000 lb. From the shape of the curve in the upper right-hand corner, it follows that the weight of the wheel increases very rapidly for drops in speed less than 15 per cent., and that

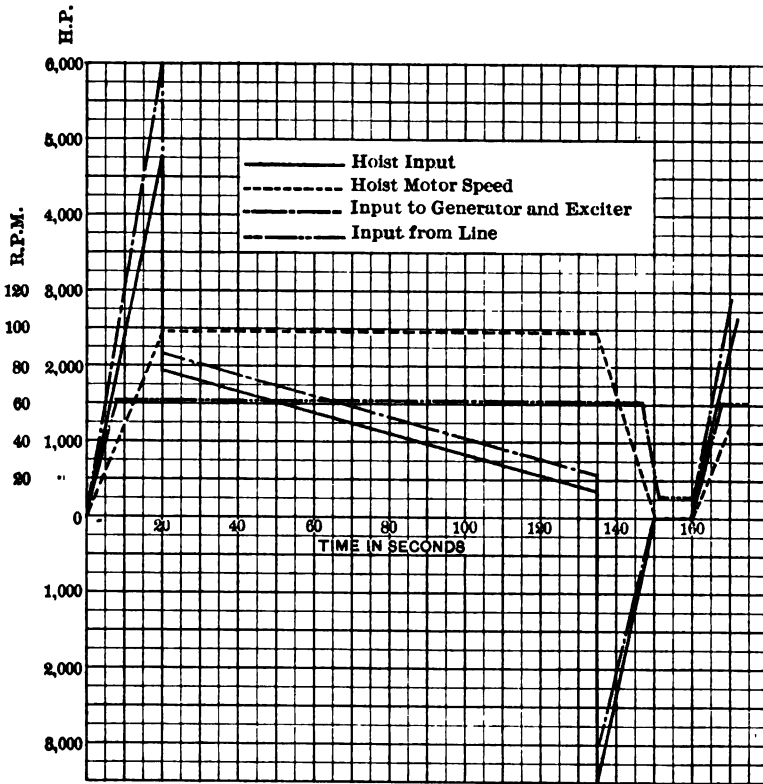


FIG. 18.—CURRENT- AND POWER-CURVES OF A BALANCED CYCLE OF THE SYSTEM SHOWN IN FIG. 15.

little is gained by increasing the drop beyond 35 per cent. On the other hand, the cost of the motor and generator decreases, and the efficiency of the induction-motor increases, and therefore the power consumed per cycle decreases, as the drop in speed decreases. The usual practice is to allow approximately 15 per cent. drop in speed for balanced operation; but as the fly-wheel must take care of the unbalanced cycle without re-

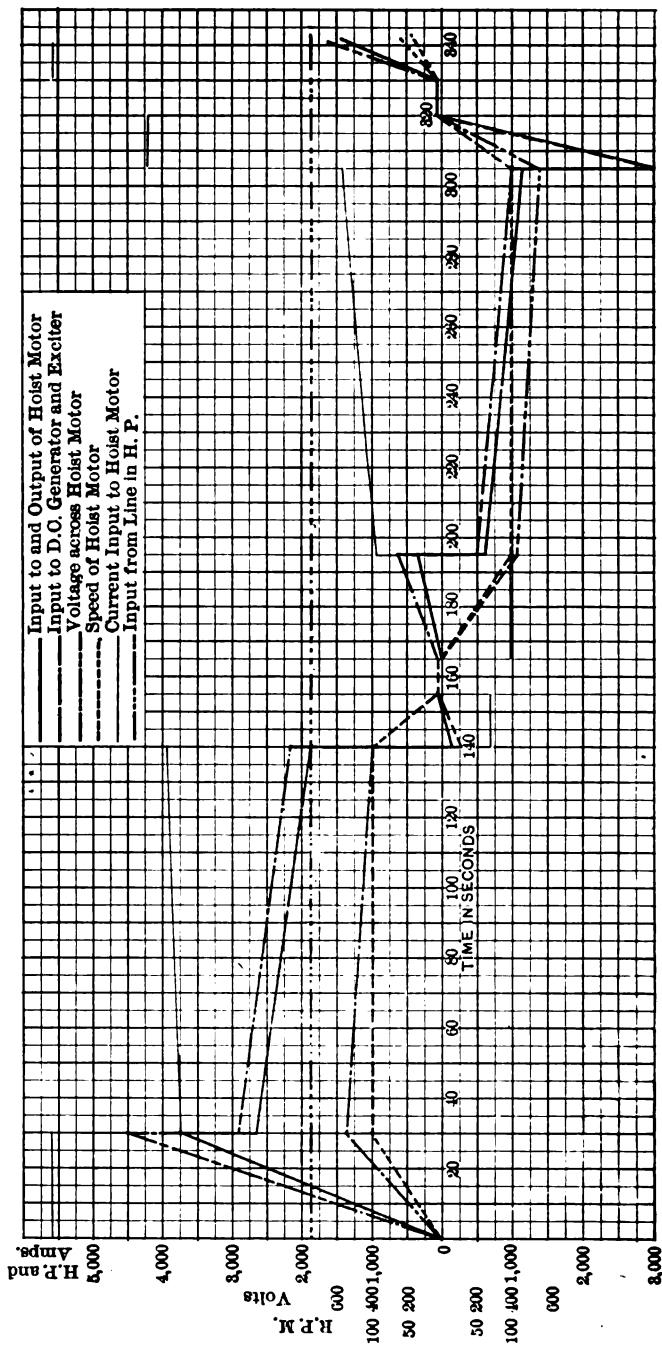
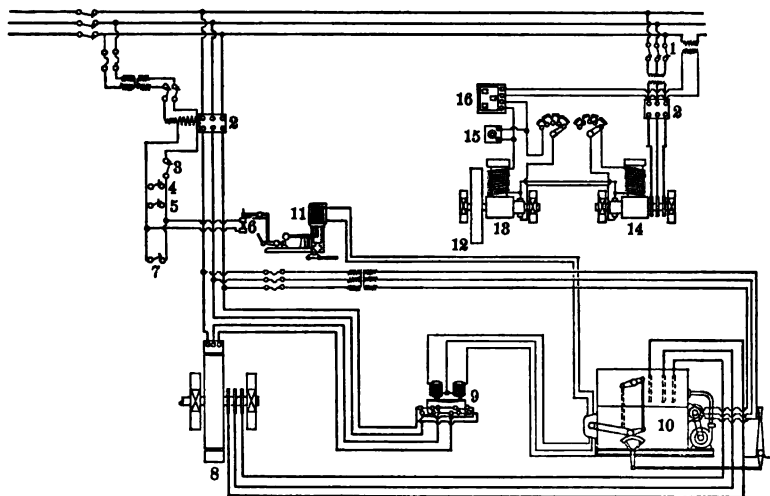


FIG. 19.—CURRENT- AND POWER-CURVES OF AN UNBALANCED CYCLE OF THE SYSTEM SHOWN IN FIG. 15.

ducing the speed of the generator so low as seriously to affect its commutation, it is necessary to vary this value considerably in special cases.

The power- and current-curves for this system are shown in Figs. 18 and 19. The drop in the power-curve of the balanced cycle during the period of rest is due to the fact that the regulator is set for the maximum condition, which in this case is hoisting unbalanced, this setting being above that required for the balanced cycle.

The fourth system is used when, for the purpose of meeting some peculiar condition, it is advisable to drive the hoist by an



induction-motor and at the same time eliminate the peaks from the station-load. The adoption of this system is warranted when the hoist is located underground at such a distance from the surface that it becomes necessary to transmit power to it by alternating current, and when the shaft is not large enough to allow the fly-wheel of the motor-generator set to be taken underground.

Fig. 20 shows this system, which, it will be noted, is the first system, to which has been added a converter equalizer, consisting of a rotary converter connected on the alternating-current side to the supply-system, and on the direct-current side to a

motor driving a large fly-wheel. The field of the direct-current motor is controlled by a regulator actuated by the line-current. When the power taken by the hoist-motor drops below the average, the field of the motor is automatically reduced, and the fly-wheel is speeded up, the power being taken from the supply-system. When the hoist-motor load exceeds the average the operation is reversed, the fly-wheel slowing down and returning power to the system.

Fig. 11 gives the current- and power-curves, which are those of the first system, to which has been added the input-curve with converter equalizer. The efficiency of this system is generally slightly lower, and the weight of the fly-wheel is slightly greater, than for the direct-current motor and the fly-wheel motor-generator set. It has the advantage, however, over the third system in that the operation of the hoist-motor is not dependent on the operation of a converter equalizer. Consequently, in the event of the failure of the latter, hoisting may be continued, providing, of course, that the capacity of the power-system is sufficient to take the load, which would be the case if the equalizer were used simply to reduce the power bill.

Either the third or the fourth system may be used where the supply-system is direct current, by substituting a direct-current motor for the induction-motor of the fly-wheel motor-generator set in the third system, and omitting the synchronous converter of the fly-wheel converter system in the fourth.

Among other systems of electric hoisting which might be mentioned is the Creplet system, in which a booster driving a heavy fly-wheel is connected in series with the hoist-motor and the supply-system. The booster is wound for the same potential as the supply-system, and the hoist-motor for twice this potential. When the hoist is idle, the hoist-motor armature is short-circuited, the booster is thus connected across the supply-system, and the speed of the fly-wheel is at its maximum. To accelerate the hoist, the short-circuit is opened, and the potential of the booster is generally reduced to zero, reversed, and brought up to full potential in the opposite direction, the power stored in the fly-wheel during the idle period being returned.

It has been proposed, and at least two installations embodying the idea are now in process of construction, to substitute

compressed air for steam. The present hoist-engines would be used, with slight modification of their valves to accommodate them to compressed air, the compressors for supplying the air to be driven by electric motors. It is impossible, however, to gather sufficient details regarding the system to predict the results which will be obtained.

A typical mine-hoist log is given in Table I., which is the condensed log for 24 hr., taken at a mine under actual conditions.

TABLE I.—*Mine-Hoist Log.*

Time in Minutes and Seconds.

Interval.	Hoisting Ore.	Hoisting Men.	Hoisting Waste.	Other Hoisting.	Shifting.	Rest.
7-8 A. M.	.....	10-2	6-37	6-28	7-39	29-14
8-9	24-5	.....	3-0	2-47	6-44	23-24
9-10	14-2	3-55	5-0	6-12	15-15	15-56
10-11	30-25	.....	12-0	1-30	8-35	7-30
11-12 M.	57-55	.....	.....	1-5	1-0	.....
12-1 P. M.	3-35	1-0	17-5	2-55	4-29	30-56
1-2	51-10	1-50	.....	1-45	4-0	1-15
2-3	20-10	.....	.....	2-40	12-5	25-5
3-4	44-0	.....	.....	0-51	5-25	9-44
4-5	.....	7-38	.....	1-25	0-38	50-19
5-6	.....	.....	.....	.....	0-35	59-25
6-7	.....	13-8	.....	1-23	0-27	45-2
7-8	21-27	.....	16-42	1-54	2-1	17-56
8-9	51-7	1-8	.....	4-57	1-59	0-49
9-10	54-17	.....	.....	1-30	1-30	2-43
10-11	48-22	1-42	.....	.....	2-53	7-03
11-12 M. M.	.....	.....	8-39	4-16	0-40	46-25
12-1 A. M.	34-51	1-52	.....	.....	0-30	22-47
1-2	53-14	.....	.....	2-49	.....	3-57
2-3	50-25	.....	.....	1-10	.....	8-25
3-4	.....	7-50	.....	25-43	1-0	25-27
4-5	.....	.....	.....	55-47	0-34	3-39
5-6	.....	.....	.....	5-14	.....	54-46
6-7	.....	.....	.....	3-09	.....	56-51

Table II. gives a condensed summary of this log, and also that of another mine under actual operating-conditions.

TABLE II.—*Summary of Table I.*

	Mine A.			Mine B.	
	Minutes.	Seconds.	Per Cent.	Approximate Minutes.	Approximate Per Cent.
Hoisting ore and waste...	628	8	43.7	428	30
Other hoisting.....	185	15	12.9	171	12
Shifting.....	77	59	5.4	120	8
Rest.....	548	38	38	721	50

The estimated distribution of power consumed for hoisting is given in Table III. - Attention is called to the close agreement between the estimates for the power consumed in hoisting ore and waste, which, in view of the fact that the estimates were made entirely independent of each other, should add considerable weight to the figures. One estimate is based on figures obtained by indicating the hoisting-engine, and the other forms the basis for the distribution of the costs of hoisting.

TABLE III.—*Distribution of Power.*

	Distribution of Power in Per Cent. of Tot a	
	Mine A.	Mine B.
Hoisting ore and waste.....	55	51
Other hoisting.....	28	23
Shifting.....	17	26

The curves in Fig. 21 give the total tons hoisted, and the total kilowatt-hours consumed (per day of 24 hr.), the kilowatt-hours consumed per ton- (2,000 lb.) foot, and the load-factor for each of the four systems when hoisting 10,000 lb. per trip in balance from vertical depths, varying from 400 to 2,600 ft., by a reel-hoist. Fig. 22 gives similar curves for hoisting 20,000 lb. of ore per trip in balance, from depths varying from 3,000 to 8,000 ft., by a cylindrical-drum hoist, the shaft making an angle of approximately 38° with the horizontal, and the depths being measured on the incline.

Table IV. gives the power-consumption for the various systems for hoisting 6,000 lb. in balance from one level in a compound shaft, the hoist load-diagram for which is given in Fig. 23. The shaft drops vertically 800 ft. and then continues for 1,320 ft. on an incline of 38° with the horizontal.

TABLE IV.—*Power-Consumption for Various Systems.*

	Power for Hoisting.	Power for Hoisting.		Total Tons Hoisted.	Load-Factor.
	Kw-hr.	Kw-hr.	Ton-ft.		
First system.....	3,900	0.00307 ^a	0.00234 ^b	786	25
Second system...	3,450	0.00272	0.00206	786	19.2
Third system.....	4,019	0.00315	0.00240	786	62
Fourth system...	4,910	0.00386	0.00295	786	63.6

^a Values are based on the total vertical lift, 1,613 feet.

^b Values are based on the total distance lift, 2,120 feet.

The values given in these curves and in Table IV. include the power consumed in "other hoisting" and "shifting," on

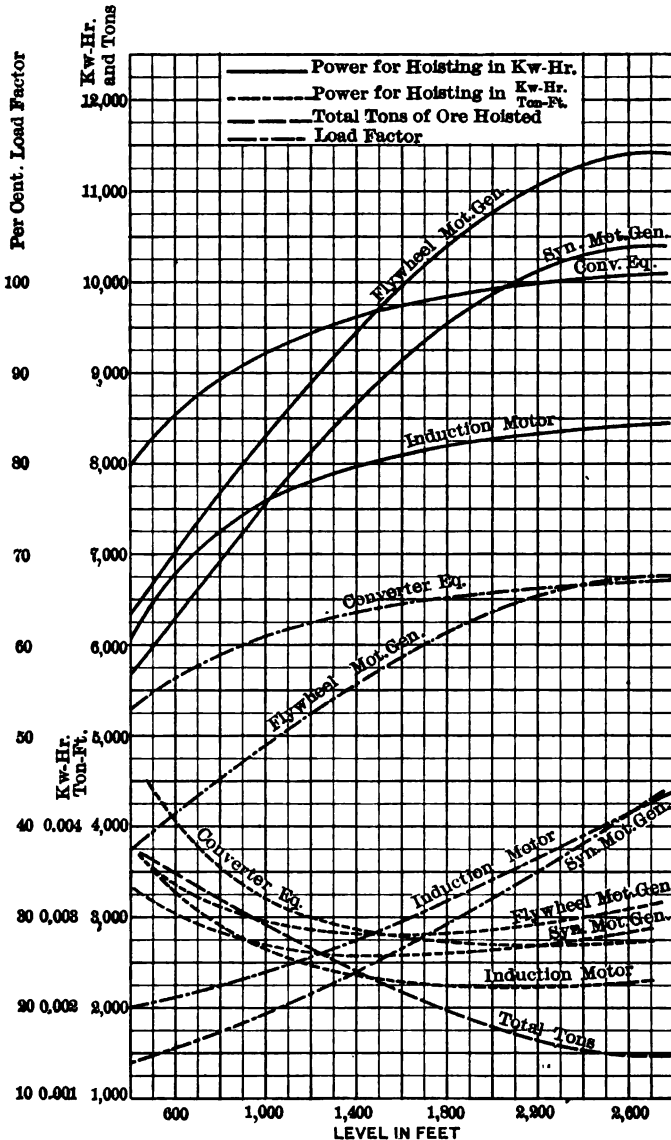


FIG. 21.—COMPARISON OF POWER-CURVES OF THE FOUR SYSTEMS, USING A REEL HOIST.

the assumption that the power consumed in hoisting ore is 53 per cent. of the total power. Also, in the values for the

synchronous motor-generator set (second system), no credit is allowed for the power returned during retardation.

The curves and Table IV. show clearly the effect of the shape of the hoist on the power consumed by the various systems. At the upper levels the period of acceleration is a large part of the total cycle, and we find the power consumed by the induction-motor hoist to be greater than that for the hoist driven by the direct-current motor, power for which is supplied by a synchronous or induction-motor-generator set. In the case of the cylindrical-drum hoist, for which the peak during acceleration is much greater than for the reel-hoist, the power consumed by the induction-motor is greater for all levels. Also, a similar relation exists in the power-curve when a converter equalizer or a fly-wheel motor-generator set is used.

If a cylindrical drum is used instead of a reel, the curves of Fig. 21 for the direct-current hoist-motors will remain practically the same, but those for the induction hoist-motor will be raised, crossing those of the synchronous motor-generator set towards the end of the curve; and if a cylindro-conical drum is substituted for the cylindrical drum of the larger hoist, the induction-motor curves of Fig. 22 will approach those for the direct-current hoist-motor.

The values for the different levels, shown by the curves, are based on the assumption that all the ore is taken from the corresponding level. Where ore is hoisted from several levels, the total power-consumption per day may readily be obtained from the power-consumption per ton-foot, or by the use of the curves of "Total Tons Hoisted" and "Power for Hoisting in Kw-hr."

While the curves given cover specific cases only, the examples chosen are typical, and by interpolating between the power consumed per ton-foot for the 8,000-ft. and that for the 2,500-ft. hoists, the power per ton-foot may be obtained for hoisting from any depth. Due correction is to be made for the inclination of the 8,000-ft. shaft by dividing the values given by 0.616 to obtain the equivalent values for a vertical shaft. From the total kilowatt-hours consumed per day and the load-factor, the cost of power for hoisting electrically can readily be obtained.

A comparison between steam and electric hoisting is given

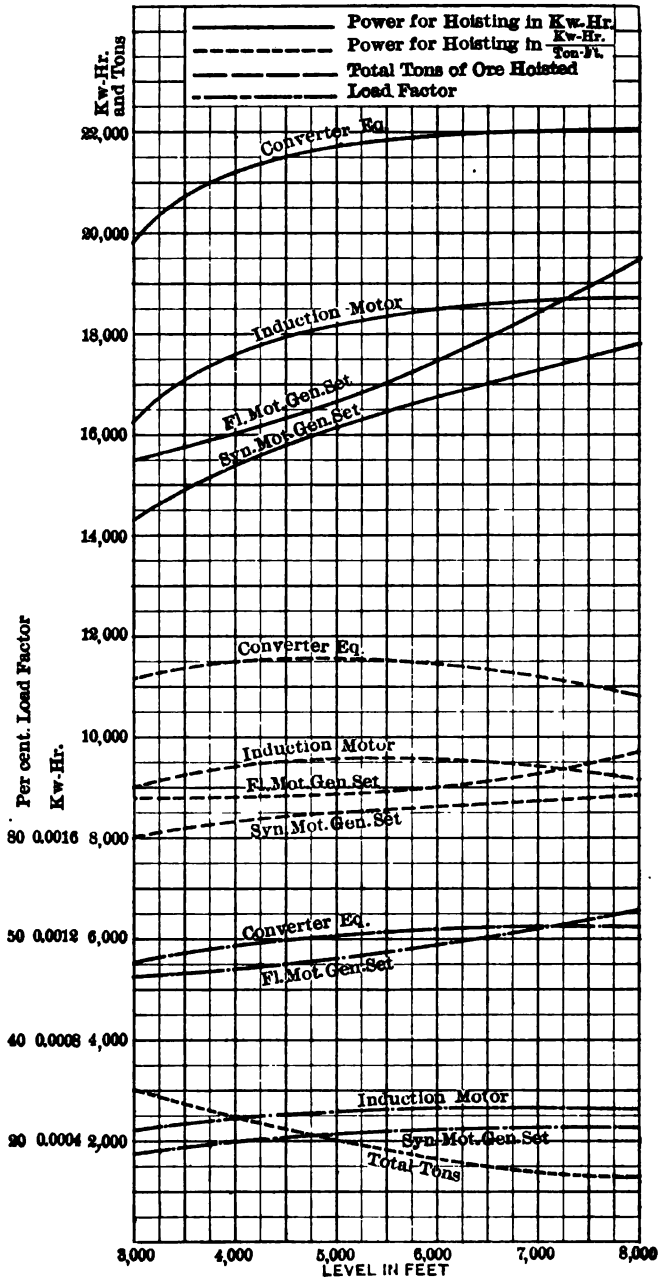


FIG. 22.—COMPARISON OF POWER-CURVES OF THE FOUR SYSTEMS, USING A CYLINDRICAL-DRUM HOIST.

in Table V., in which the coal-and-rock ratio for each is given for the 2,000-ft. and the 6,000-ft. levels respectively. In determining these values, it is assumed that the steam hoisting-engines are non-condensing, that the steam-consumption is 65 lb. and 55 lb. per indicated horse-power-hour respectively for the large and small hoists, and that power for the electric hoists is supplied from a modern steam-turbine station using units of 1,000 kw. each or larger for the small hoist, and 2,500 kw. or larger for the larger hoist.

In determining these ratios, 10 per cent. has been added to the total kilowatt-hours per day as given in the curves, to cover the losses in transmission.

TABLE V.—*Comparison of Steam and Electric Hoisting.*

	Coal Burned. Tons per Day.	Ore Hoisted. Tons per Day.	Tons Ore. Tons Coal
Hoisting from 2,000-ft. level, small hoist :			
Steam-hoist,	47.0	1,780	40
Electric hoist :			
First system,	13	1,780	137
Second system,	15	1,780	119
Third system,	16	1,780	110
Fourth system,	15	1,780	119
Hoisting from 6,000-ft. level, large hoist :			
Steam-hoist,	65.5	1,580	24
Electric hoist :			
First system,	23	1,580	69
Second system,	24	1,580	66
Third system,	25	1,580	63
Fourth system,	27	1,580	59

In addition to the saving in fuel, which may be realized by the use of electric hoists, there is a very material reduction in the labor, the cost of which is chargeable against the hoist. This may amount to the wages of one or two men in the boiler-house if power is developed by the mining company, or of the whole boiler-house force if power is purchased, and frequently the wages of one man in the hoist-house.

So many factors which vary between wide limits for different localities enter into the comparative costs of hoisting electrically and by steam, that each individual case must be treated by itself; but the following comparison will serve as an indication of the general result of a more detailed investigation.

Take, for example, the reel-hoist, the power-curves for which

are shown in Fig. 21, and assume that the average condition of hoisting is that represented by hoisting from the 2,000-ft. level; that good steaming-coal can be purchased for \$3.50 per ton; that power can be purchased for the equivalent of 1.1 cents per kilowatt-hour, on a 50-per cent. load-factor, and, if steam driven, that the engine will be non-condensing.

In order to obtain a load-factor of 50 per cent., it will be necessary to install either the third or fourth system of electric

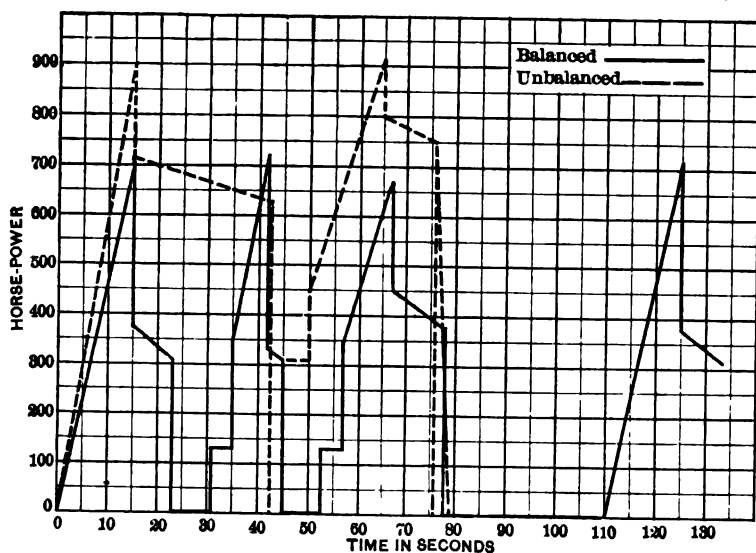


FIG. 23.—HOIST-LOAD DIAGRAM FOR 6,000-LB. LOAD IN A COMPOUND SHAFT.

hoisting, and, to be conservative, let it be assumed that the third is chosen.

Total cost of power per year for electric hoist at 1.1 cents per kilowatt-hour,	\$35,300
Fixed charges on the excess cost of the electric over the steam hoist (approximately \$25,000),	2,500
	\$37,800
14,100 tons coal at \$3.50 per ton,	\$49,350
Boiler-house force (3 men at \$3.25 per day),	2,925
One oiler,	900
	\$53,175
	37,800
Approximate annual saving with electric hoist,	\$15,375

As this saving of \$15,375 is the result of an additional expenditure of \$25,000 for the electric hoist, it is proper for a new installation to base the rate of interest equivalent to this saving on this additional first-cost, from which it follows that the interest realized on this investment is 61.5 per cent. If, on the other hand, it is a question of replacing an existing steam-hoist, the interest should be based on the total cost of the electric installation, in which case the very substantial rate of 80 per cent. will be realized.

The hoist, above all other parts of the mine-equipment, must be kept in commission at all times, and this fact must be borne in mind in installing an electric hoist. The transmission-lines must be carried on substantial poles over a well-cleared right-of-way, duplicate lines being installed where possible, and the lines being adequately protected against disturbances from lightning. If these precautions are properly taken, the electric can be made as thoroughly reliable as the steam-driven hoist.

V. SUMMARY.

Summing up, the advantages of the electric hoist are: first, greater economy, resulting from the centralization of the development of power in a large central electric station, favorably located for the economical development of power, and from a reduction in the operating-force, from the increased life of the rope, and the greater life of the brakes; second, greater safety in operation; third, especially, adaptation for underground installations; and fourth, the fact that it permits of the utilization of water-power, which is frequently available in mining-districts.

The Combustion of Coal.

**BY JOSEPH A. HOLMES, WASHINGTON, D. C., AND HENRY KREISINGER,*
PITTSBURG, PA.**

(Pittsburg Meeting, March, 1910.)

At the Mining Experiment Station of the U. S. Geological Survey, in Pittsburg, an investigation of the process of combustion is being carried on in a specially-designed furnace having an unusually long combustion-chamber. This work is conducted by a committee consisting of H. Kreisinger, mechanical engineer; Dr. J. C. W. Frazer, chemist; and Dr. J. K. Clement, physicist. The problem, essentially one of physical chemistry, is extremely interesting to all who are concerned in the burning of coal or the construction of furnaces.

The main object of these experiments is to ascertain the relation between the amount of the volatile combustible driven from the coal and the combustion-spaces necessary to burn it completely. Our best steam-coals vary from 15 to 45 per cent. of fixed combustible. The greater part of the latter is burned on the grate; but the volatile combustible leaves the freshly-charged coal and must be burned in the combustion-space. If this space is not large enough, the volatile combustible will leave the furnace only partly burned, and the result will be a considerable heat-loss and a smoky stack. Strictly speaking, the factor which determines the completeness of combustion of the volatile matter, after it has been mixed with a certain amount of air, is the length of time the mixture is allowed to remain in the combustion-space; but this length of time depends on the extent of the space itself. Let us suppose, for instance, that, when a given coal is burned at a certain standard rate, the volume of the volatile combustible driven off per second is 10 cu. ft. Adding, say, 10 cu. ft. of air, the volume of the resulting burning mixture is increased to 20 cu. ft. If the combustion-space is 20 cu. ft., the burning mixture will stay in it,

* U. S. Geological Survey.

on the average, 1 sec.; if 40 cu. ft., it will remain, on the average, 2 sec.; whereas, if only 10 cu. ft., it can stay only half a second. It is therefore probable that in the burning of a given coal the completeness of combustion of the volatile combustible depends on the extent of the combustion-space. (For the sake of simplicity in the above illustration, the effect of temperature on the volume of the combustible mixture has not been considered.)

Effect of the Nature of Coal on the Extent of Combustion-Space Required.—Different steam-coals evolve different volumes of volatile combustible, even when burned at the same rate. Coal containing 45 per cent. of volatile matter evolves a much greater volume of gases and tar-vapors than that which contains only 15 per cent. Consequently, a furnace having a much larger combustion-space will be required to burn the former as completely as the latter.

The extent of combustion-space thus required depends not only on the volume of the combustible mixture, but also on its chemical composition. Thus, the volatile combustible of a low-volatile coal, when mixed with an equal volume of air, may require 1 sec. for complete combustion in a given space, while 2 sec. may be required to burn with the same completeness the same volume of the volatile combustible from a high-volatile coal. In other words, the combustion-space required to burn various kinds of coal is not directly proportional to the volatile matter contained in the coal.

Effect of the Rate of Combustion on the Extent of Combustion-Space Required.—With the same coal, the volume of the volatile combustible distilled from the fuel-bed per unit of time varies as the rate of combustion. Thus, when the rate of combustion is double that of the standard, the volume of gases and tar-vapors driven from the fuel is about doubled. To this increased volume of volatile combustible an equal volume of air must be added; and if the mixture is to be kept for only the same length of time within the combustion-space, that space should be about twice as large as for the standard rate of combustion. The space required for complete combustion varies, therefore, not only with the nature of the coal but also with the rate of firing.

Effect of Air-Supply on the Extent of Combustion-Space Required.—Another factor which influences the extent of the combustion-space is the amount of air mixed with the volatile combustible. Perhaps within certain limits the combustion-space may be decreased when the supply of air is increased. On this point, however, anything said at present would be speculative. The facts must be determined experimentally.

Effect of Rate of Heating of Coal on the Extent of Combustion-Space Required.—There is still another and a very important factor influencing, for any given coal and any given air-supply, the extent of the combustion-space required—namely, the rate of heating of the coal when feeding it into the furnace. Our so-called “proximate” analysis of coal is indeed only very approximate. When the analysis shows, say, 40 per cent. of volatile matter and 45 per cent. of fixed carbon, it does not mean that the coal is actually composed of so much volatile matter and so much fixed carbon, but simply that at a certain rate of heating, given by certain standard laboratory-conditions, 40 per cent. of the coal has been driven off as “volatile matter.” If the rate or method of heating were different, the amount of volatile matter driven off would also be different. Chemists can testify how difficult it is to get accurate checks on “proximate” analysis. To illustrate this point further, we may refer to the operation of the up-draft bituminous gas-producer. In the generator of such a producer, the tar-vapors leave the freshly-fired fuel, pass through the wet scrubber, and are finally separated by the tar-extractor as a black, pasty, semi-liquid substance. If this “tar” is subjected to the standard proximate analysis, it will be found that from 40 to 50 per cent. of it is fixed carbon, although the tar left the gas-generator as “volatile matter.” The fact to be emphasized is, that different rates of heating of high-volatile coals will not only drive off different percentages of volatile matter, but that this material itself varies greatly in chemical composition and physical properties, especially as regards inflammability and rapidity of combustion. We may therefore conclude that the combustion-space required for complete oxidation of the volatile combustible depends, in some degree, on the method of charging the fuel; that is, on the rapidity with which the fresh fuel is heated.

In summary, it may be said that the combustion-space re-

quired to obtain a practically complete combustion depends on: (a) the nature of the coal; (b) the rate of combustion; (c) the supply of air; and (d) the rate of the heating of the fuel.

To determine the influence of each of these factors is the object of the experiments under discussion.

Description of Furnace.—The furnace used in these investigations is fed with a standard Murphy mechanical stoker. The special feature of the furnace is a large combustion-space, 8 by 3 ft. in cross-section and nearly 40 ft. long. To the volatile combustibles leaving the fuel on the grate, air is added through numerous small openings above the grate; the mixture then passes through the combustion-space, and the products of combustion are discharged into the setting of a Heine boiler.

The difference of pressure necessary to move the gases through the furnace is obtained by two fans, one of which exhausts the gases from the setting of the Heine boiler (into which they are discharged from the long combustion-space), while the other forces air under the grate of the stoker. During a test, the speed of the two fans is so adjusted that the pressure of the gases in the long combustion-chamber is slightly below that of the atmosphere, the object being to reduce to a minimum the leakage of air into the combustion-chamber, without making observation at the peep-holes disagreeable through jets of hot gases through them.

Figs. 1 and 2 show the general appearance and connections of the furnace. Fig. 2 indicates the methods of collecting the samples of gas. Three samples are being collected through the water-cooled tubes rising through and above the top of the furnace, as seen just to the right of the left window; and another through a similar tube entering the furnace through the observation-hole near and to the left of the table on which are the bottles in which the samples of gas are being collected.

Some of these water-cooled tubes contain three separate smaller tubes, each starting from the top, but ending at different distances; and it is therefore possible to collect at the same time three samples of gas through each main tube, or 12 samples in all, each coming from a different point in this cross-section of the furnace. And inasmuch as there are seven such cross-sections, and two additional observation-holes nearer the fire-box, it is possible, though perhaps never necessary, to col-

lect 80 or 90 samples of gas during the same 20-min. period, each sample representing the average of the gases passing the open end of its small tube during this period.

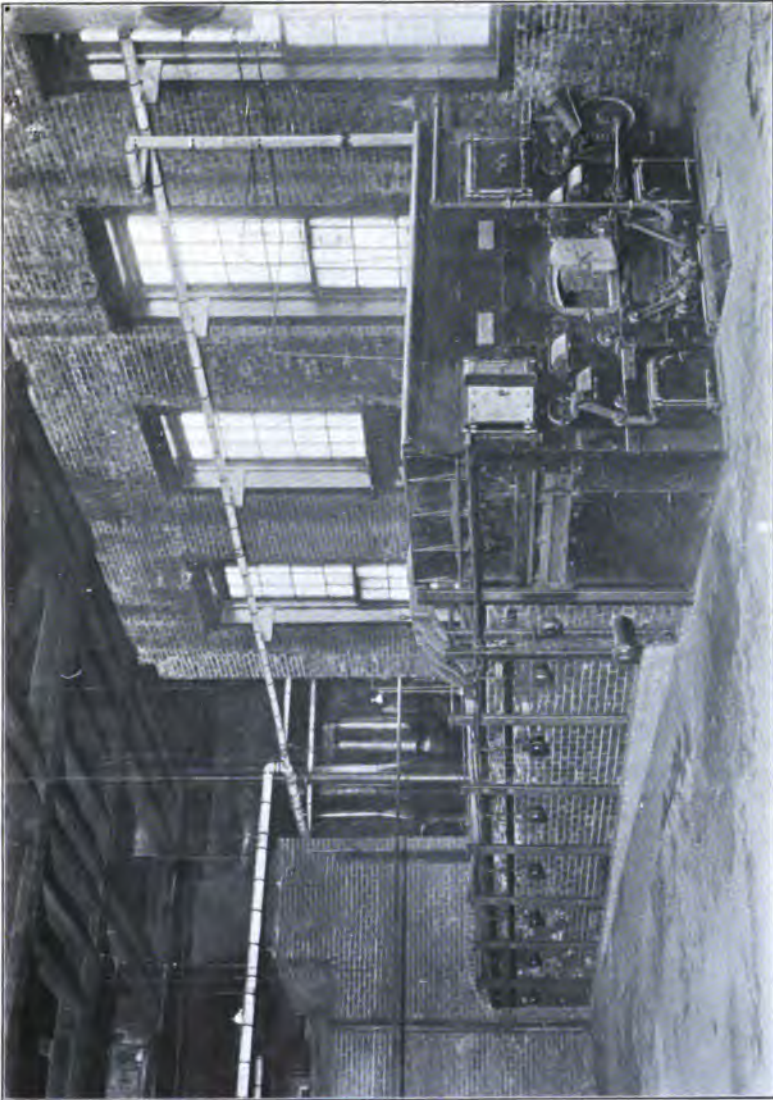


FIG. 1.—FURNACE WITH LONG COMBUSTION-CHAMBER.

Figs. 3 and 4 show longitudinal, horizontal and vertical sections of the furnace, and Figs. 5 and 6 show two typical cross-sections of the furnace. A 150 h.p. Murphy mechanical stoker is at the front end of the furnace, and a 220-h.p. Heine safety

boiler at the rear end. The observation-holes at 5-ft. intervals are shown through the left side-wall in Fig. 3.

The side-walls of this furnace are double, the inner being 9

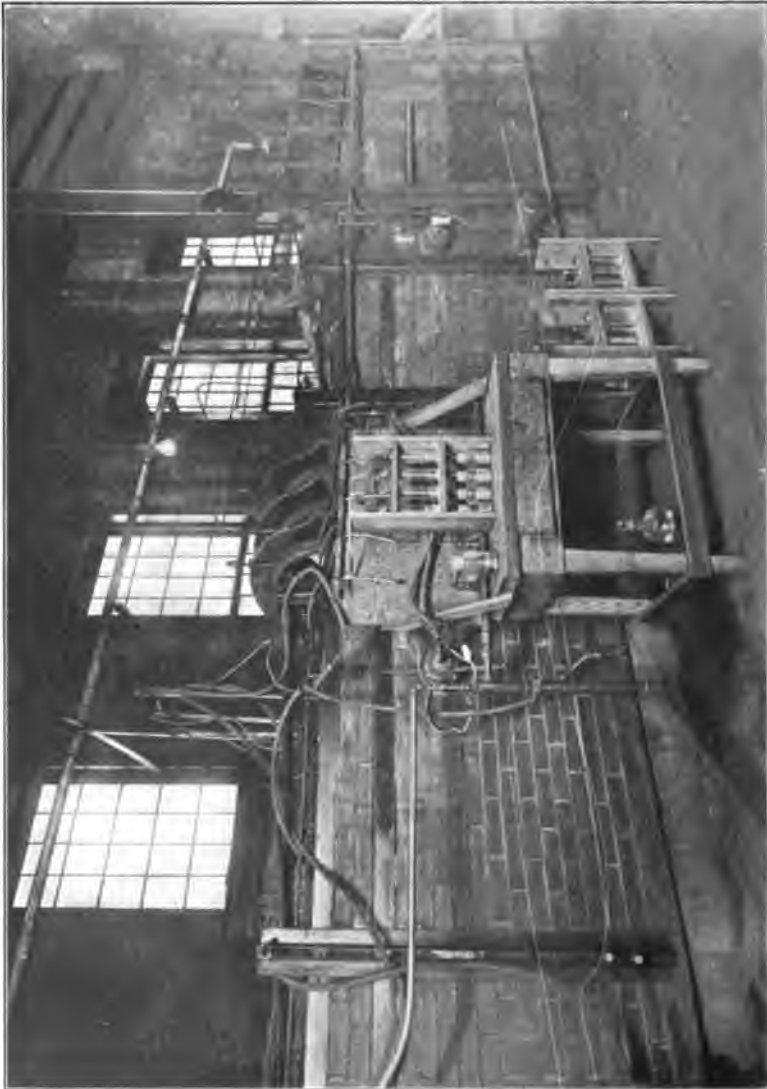


FIG. 2.—METHOD OF COLLECTING SAMPLES OF COMBUSTION-PRODUCTS.

in. thick and made entirely of fire-brick, while the outer is 8 in. thick and faced with red pressed-brick. Between the two is a 2-in. air-space. The arch forming the roof of the furnace is also double, the inner arch being of fire-brick, 9 in. thick, the

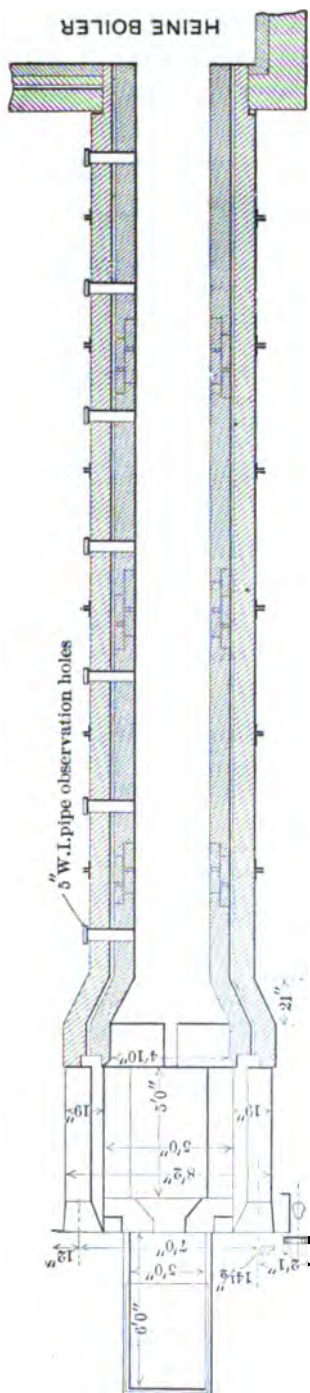


FIG. 3.—LONGITUDINAL HORIZONTAL SECTION OF THE FURNACE.

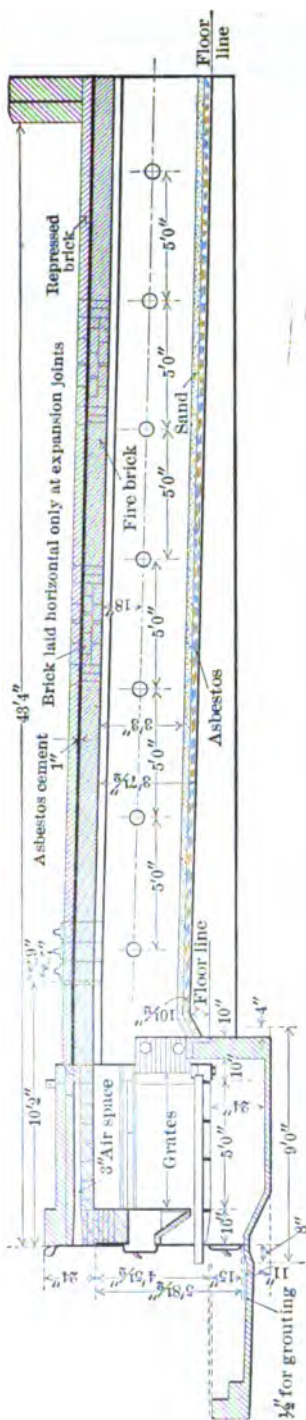


FIG. 4.—LONGITUDINAL VERTICAL SECTION OF THE FURNACE.

The Scope of the Experiments.—With the object explained in the preceding paragraphs, the following series of experiments has been planned :

Six or eight typical coals having been selected, each representing a certain group of coals of nearly the same chemical composition, each of these coals will be investigated in a separate series of tests, the series consisting of several sets of tests, made with all conditions constant excepting the one, the effect of which on the size of the combustion-space is to be investigated. Thus, a set of four or five tests will be made, varying the rate of combustion from 20 to 80 lb. of coal per square foot of grate per hour, keeping the supply of air per pound of combustible and the rate of heating constant. This set of tests will show the effect of the rate of combustion on the extent of combustion-space required to obtain a practically complete result. Other variables, such as the composition of the coal, the supply of air, and the rate of heating, will remain constant.

Another set of four or five tests will be made with the same coal and at the same rate of combustion, but with a varying supply of air. This set of tests will be repeated for two or three different rates of combustion. Thus, each of these sets will give the effect of air-supply on the extent of required combustion-space, when the coal and the rate of combustion remain constant.

Still another set of tests should be made, in which the time of heating the coal while feeding it into the furnace is varied from 3 to 30 min. In each of the tests of this set, the rate of combustion and the air-supply would be kept constant, and the set would be repeated for two or three rates of combustion and two or three different supplies of air. These tests would give the effect of the rate of heating of fresh fuel on the combustion-space required to burn the distilled volatile combustible. These latter experiments will require a modification in the stoker-mechanism, and on that account may be put off until all the other tests on the selected typical coals are completed. As the investigation goes on, enough may be learned to permit the reduction of the number of tests in each series.

The chemical changes in the gases during the processes of combustion as these gases travel from the fire-box through the elongated furnace, and the completeness of combustion in the

successive cross-sections of the stream of gases, are determined mainly by the chemical analysis of samples of gases collected through the openings in the furnace at these points. The first of these cross-sections where gas samples are collected passes through the middle of the bridge-wall; the others are placed at intervals of 5 ft. through the entire length of the furnace. Measurement of the temperatures of the gases and direct observation of the length and color of flames and of any visible smoke will be also made through the side peep-holes. These direct observations, together with the gas-analysis, will furnish enough data to determine the length of the travel of the combustible mixture before attaining practically complete combustion. In other words, these observations will determine the necessary combustion-space for various kinds of coal, burned under given conditions. Direct observations, and the analysis of gases at sections nearer to the stoker than the one at which the combustion is practically complete, will show how the process progresses towards completion. This information will be of extreme value in determining the loss of heat, due to incomplete combustion, caused by shortening the combustion-space.

Method of Collecting Gas-Samples.—The collection of gas-samples presents a difficult problem, when it is considered that the temperature of the gases in the furnace ranges from 2,400° to 3,200° F., and therefore that the samples must be collected with water-cooled tubes. About twenty-five preliminary tests have shown that the composition of the gases at the cross-sections near the stoker is not uniform, and that more than one sample must be taken from each cross-section. It has been decided to take nine samples from the cross-section immediately back of the stoker, and to reduce the number in the sections following, according to the uniformity of the gas-composition. Thus, about 35 simultaneous gas-samples must be taken for each test. These samples will be subjected to a complete analysis, and not merely to the usual determination of carbon monoxide, carbon dioxide, and oxygen.

It is also realized that some of the carbon-hydrogen compounds which, at the furnace-temperature, exist as heavy gases, are condensed to liquids and solids when cooled in the sampling-tubes, where they settle and tend to clog the tubes. To neglect the presence of this form of combustible would intro-

duce considerable errors in the determination of the completeness of combustion at any of the cross-sections. To meet this difficulty, special water-cooled sampling-tubes have been constructed and equipped with filters which separate the liquid and solid combustible from the gases. The contents of these filters also are subjected to complete analysis. To obtain quantitative data, a measured amount of gases must be drawn through these filtering sampling-tubes.

Measuring of Temperatures.—At present the only possible known method of measuring the temperature of the furnace-gases is by optical and radiation pyrometers. Platinum thermocouples are soon destroyed by the corrosive action of the hot gases. The pyrometers used at present are the Wanner optical pyrometer and the Fèry radiation pyrometer.

The Flow of Heat Through Furnace-Walls.—An interesting side-investigation has been developed in the study of the loss of heat through the furnace-walls. As already observed, the side-walls of this experimental furnace contain a 2-in. air-space, which, in the roof, is replaced with a 1-in. layer of asbestos. To determine the relative resistance to heat-flow of the air-space and the asbestos layer, 20 thermo-couples were imbedded, in groups of four, to different depths at three places in the side-wall and at two places in the roof. In the side-wall, one of the thermo-couples of each group was placed in the inner wall near the inner surface; the second thermo-couple was placed in the same wall, but near the surface facing the air-space; the third thermo-couple was placed in the outer wall near the inner surface; and the fourth was placed near the outer surface in the outer wall. In the roof the thermo-couples were placed in the brick near the surfaces on each side of the asbestos layer. These thermo-couples have shown that the temperature-drop across the 2-in. air-space was much less than across the 1-in. layer of asbestos; in fact, that it was considerably less than the temperature-drop through the same thickness of the brick wall.

The results so far obtained indicate that, as far as heat-insulation is concerned, air-spaces in furnace-walls may be undesirable, and suggest that in furnace-construction a solid wall may be a better heat-insulator than a wall of the same total thickness containing an air-space. If it is necessary to build a fur-

nace-wall in two parts on account of unequal expansion, it may be wise to fill the space between the two walls with some solid, cheap, non-conducting material, such as ash, sand, or crushed brick. A more detailed account of these experiments has been given in *Bulletin No. — of the U. S. Geological Survey*, entitled "The Flow of Heat Through Furnace-Walls."

Further experiments will be conducted concerning this phase of the subject. These combustion-investigations in the elongated furnace are being preceded and supplemented by chemical and microscopical investigations of the coals with a view to determining the origin and the hydrocarbon composition of each of the coals under examination.

Pan-Amalgamation: an Instructive Laboratory-Experiment.

Reply to the discussion of the paper of Messrs. Hofman and Hayward by George W. Riter, *Bulletin* No. 39, March, 1910, pp. 249 to 251.

H. O. HOFMAN and C. R. HAYWARD, Boston, Mass. (communication to the Secretary*):—The discussion of our paper by George W. Riter is of considerable interest in that it shows how omissions on the part of a writer render obscure certain parts of a paper, and how unsatisfied expectations on the part of the reader lead him to put a wrong interpretation upon what has been written.

Taking up the criticisms in the order in which they have been made:

The paper is accused not only of failing to clear up disputed points in pan-amalgamation, but of committing the fault of increasing the confusion that may still exist, in explaining the reactions that govern the process. The main object of the paper was to show that pan-amalgamation can be made to serve as a valuable typical experiment for teaching a student how to adapt a metallurgical process to the treatment of a given ore. At the same time this laboratory-experiment supplements the class-room exercise; in addition, it interests the student, in that the results obtained are quantitative and of such a character that they can be used as a basis for large-scale treatment of the ore under consideration; and lastly, as carried out at the Massachusetts Institute of Technology, the summarizing of the results of a series of ten experiments is accomplished in a few days, before the attention of the student is diverted by other metallurgical work. The study of disputed points in pan-amalgamation did not come under consideration at all. In fact, if this had been the object, the manner of going to work would have taken an entirely different character. An example of students' work along this line is given later.

The supposition in the paper that each test-lot of 1,800 g. of ore contained exactly 5.499 g. of silver is attacked, and the sug-

* Received Mar. 26, 1910.

gestion is made that this was improbable. As the method of preparing the ore for the tests was not given, this criticism is justified; it will disappear, however, when the manipulations are described. The lot of ore was crushed to pass a 80-mesh sieve, mixed thoroughly on the crusher floor, and sampled by fractional selection, every third shovel being reserved, until the lot was reduced to about 50 lb.; this was further cut down by means of a split-shovel, etc., to furnish two 5-lb. samples. These were assayed by crucible- and scorification-methods, and the results were corrected by determining the losses due to scorification and cupel-absorption. The ore was packed into air-tight wooden boxes, each holding about 60 lb., and stored. Whenever a box was taken out for class-work, it was emptied and the contents were thoroughly mixed. The procedure in handling the ore justifies the assumption that any uneven distribution of silver due to a possible unmixing in storage was corrected before the ore was charged into the pan, and the acceptance of the original assay, and with it the presence of 5.499 g. of silver in 1,800 g. of ore, was therefore warranted.

The third objection, that an excess of salt was used over that which the water could dissolve, holds good, and we plead guilty.

In the paper the statement was made (p. 526) that it did not seem clear why the extraction in silver, high with an addition of 6 per cent. of salt, should decrease with 10 per cent. and then rise again, and that the anomaly required further investigation. In a recent series of tests, the highest percentage of salt was given to pan No. 1 and no salt to pan No. 10, instead of having the reverse order as usual, because it was suspected that the fall in extraction might have something to do with the working of the pans. We were led to this idea, because with the style of pan formerly used in the laboratory, some pans always gave better results than others, but in the present pans no such discrepancies had been noticed, as the pulp-current always appeared to be uniform. In Fig. 1 the dotted curve represents the line given in the original paper; the full-drawn curve shows the results obtained by the last series. Here, as was expected, the extraction increased quickly with an addition of from 1 to 6 per cent. of salt, then more slowly with from 6 to 10 per cent., and remained practically unchanged when more than 10 per cent. was used. The quicker rise of the new curve and its gen-

eral position above the older one are probably due to the time of grinding having been changed from 1.5 hr. to 1 hour.

As to the use of blue vitriol in an iron pan, the fact that iron precipitates copper was not overlooked; it could not well be, considering the weight and copper-content of the retort-silver obtained by these tests. Nevertheless, experiments were carried out with an addition of blue vitriol, as, according to practically all reliable literature on pan-amalgamation, this salt is one of the first reagents with which to experiment for an increase in the yield of silver. The conclusion drawn from the results, that

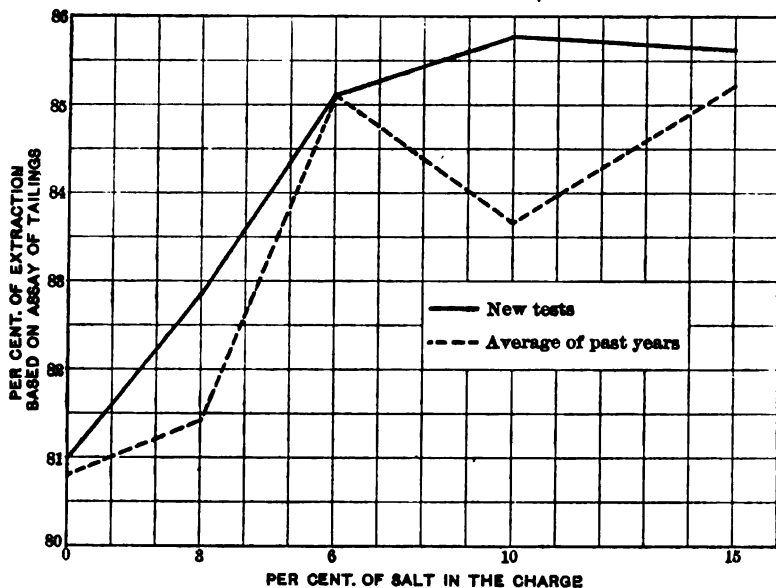


FIG. 1.—CURVES SHOWING EFFECT OF VARYING THE PERCENTAGE OF SALT.

blue vitriol had no beneficial effect, in fact decreased the extraction with the ore under consideration, is not misleading, but absolutely exact.

We may add that, in connection with the tests with blue vitriol in iron pans, experiments were carried on in copper pans of the same construction, the copper containing 1 per cent. of silicon in order to reduce the wear. As grinding in copper pans is not permissible, the pulp was previously ground to pass a 100-mesh sieve. The extraction of silver based on the tailings-assay was unsatisfactory; basing a yield on the silver recovered in the amalgam was not feasible on account of the practical impossibility of cleaning-up the pan. Work in copper pans

was therefore dropped. If pan-amalgamation were a live issue, it might be worth while to try the bronze pans as used in the Franke *tina* process at the Huanchaca mine, Bolivia.¹

The results of Mr. Riter with the ore that he was treating in a large pan-mill are of interest as far as they go; they would have been more valuable if he had told us more about the character of the ore. However, he falls into the error of making "hasty generalizations," which tend "towards further confusion" of a subject that "is incomplete and full of conflicts"—just the points that we avoided, and that he read into our text, although they are not there. In carrying on a metallurgical investigation, accurate conclusions can only be arrived at if a test or a series of tests is so planned as to determine the status of not more than one variable. As soon as you ask your experiment to give an answer at the same time to more than one question, you are sure to go astray.

We can heartily indorse the recommendation of the works of Percy and Collins on the metallurgy of silver. All the books of Percy are of permanent value, because he studied critically the metallurgical chemistry of the metals he was discussing and supplemented by original experiment any gaps that he found in his study. Even if Percy's *Silver and Gold* was somewhat out of date as regards practice when it appeared in 1880, in our day we go back to it when a question as to the metallurgical behavior comes up, to see whether he has said anything about it. Of Collins's *Metallurgy of Silver* we are awaiting a new edition, in which we may expect to find the new available material carefully chronicled and sifted, as is the case in the original work.

As the conclusions of Mr. Riter with regard to the treatment of a certain ore in an iron pan mention the behavior of silver sulphide, some data taken from the records for 1899 of the metallurgical laboratory of the Massachusetts Institute of Technology may be given to supplement the general knowledge available at present. The leading statements regarding the behavior of silver sulphide are those of Percy,² Schnabel,³ Adams,⁴

¹ *Engineering and Mining Journal*, vol. xxxviii., No. 8, p. 121 (Aug. 23, 1884).

² *Metallurgy: The Art of Extracting Metals from Their Ores. Silver and Gold.*—Part I., p. 74 (London, 1880).

³ (Translated by H. Louis) *Handbook of Metallurgy*, vol. i., p. 743 (1905).

⁴ *Engineering and Mining Journal*, vol. xi., No. 15, p. 233 (Apr. 11, 1871).

Huntington,⁵ and Rammelsberg.⁶ Percy says that silver sulphide subjected to the action of an aqueous solution of sodium chloride with access of air gives no silver chloride. Schnabel records that silver sulphide is slowly decomposed by quicksilver, with the formation of mercuric sulphide, and that the decomposition is more rapid in the presence of iron, especially upon heating. J. M. Adams found that an addition of salt to the pan did not chloridize the silver in the ore, but had a stimulating effect upon the extraction, as the yield in silver was always higher when salt was present than when it was absent. Huntington's work shows that quicksilver extracts from silver sulphide in the presence of sodium chloride, sand, and water about 87 per cent. of the silver, while the yield is only 29 per cent. in the absence of salt. Rammelsberg found that silver sulphide was decomposed only slowly by quicksilver in the presence of water at 100° C.; the yield of 12 per cent. was increased rapidly to 95.2 per cent. with the addition of iron.

In the experiments carried out in 1899, the finely-divided silver sulphide was prepared⁷ by fusing together silver, sulphur, and carbonate of potash and leaching the cake in the water. It may be added that the sulphide obtained is a slimy mass, which settles very slowly and is extremely difficult to wash completely. Some silver sulphide was prepared by precipitation from a nitrate solution by means of hydrogen sulphide. No difference was noticed in the behavior between the sulphides prepared in the dry and in the wet way. An artificial ore was made up by mixing 60 per cent. of quartz, ground through a 40-mesh sieve, and 40 per cent. of fire-clay. This proportion was chosen, as it proved to furnish the most satisfactory pulp-current. Enough silver sulphide was added to the mixture to furnish an ore assaying 100 oz. of silver to the ton.

The pan-charges were made up of 1,200 g. of quartz, 800 g. of clay, 800 g. of water, and 400 g. of mercury. The time of amalgamating was 90 min., and the temperature of the pulp about 70° C.

1. Amalgamation in a copper pan with hydrant-water gave

⁵ *Engineering and Mining Journal*, vol. xxxiv., No. 12, p. 150 (Sept. 16, 1882).

⁶ *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate*, vol. xxix., p. 191 (1881); *Engineering and Mining Journal*, vol. xxxii., No. 22, p. 354 (Nov. 28, 1881).

⁷ Berthier, *Traité des Essais*, vol. ii., p. 781 (1834).

65 per cent. extraction ; with hydrant-water and 1 per cent. by volume of H_2SO_4 , sp. gr. 1.84, gave 68 per cent. extraction ; with hydrant-water, and salt to the amount of 5, 10, and 15 per cent. of the weight of the ore, gave, respectively, 84, 94, and 96 per cent. extraction.

2. Amalgamation in an iron pan with hydrant-water, and salt to the amount of 5, 10, and 15 per cent. of the weight of the ore, gave, respectively, 37, 70, and 68 per cent. extraction.

The results show that acidifying the pulp increases slightly the yield in silver, that an addition of salt has a very favorable effect, and that copper acts more energetically than iron.

3. Amalgamation in a copper pan with distilled water—the quartz and clay having been first digested with hot distilled water until all soluble salts had been extracted—was carried on to see whether the decomposition of the silver sulphide was due to chemical or to galvanic action. The electric conductivity of the water after a charge of water, mercury, and quartz-clay mixture had been worked was found to be 28 times as great as the conductivity of the original distilled water, showing that the preliminary digestion had not been sufficient, and that in the amalgamation some salts had gone into solution ; an addition of silver sulphide to the pulp and working again under standard conditions, increased the conductivity only three times above the last figure, proving that only a small amount of the sulphide had been rendered soluble. The conclusion is that the decomposition of silver sulphide is mainly chemical and only slightly electrolytic.

4. Amalgamation in a copper pan with hydrant-water, salt to the amount of 10 per cent. of the weight of the ore, and an addition of 5 and 10 per cent. of galena, gave, respectively, 88 and 85 per cent. extraction ; 5 and 10 per cent. of chalcopyrite gave 80 and 85 per cent. extraction, showing that the presence of these base-metal sulphides has a harmful effect.

The data furnished are not sufficiently complete to settle definitely the manner and the rate of decomposition of silver sulphide, but they show the trend of the reaction and indicate the yield that may be expected under conditions resembling those of the experiments. The subject has not been carried further, as the interest in pan-amalgamation has decreased in recent years. The manner of carrying on experimental work of this kind retains its original value.

Glass Mine-Models.

Discussion of the paper of Edmund D. North, presented at the Spokane meeting, September, 1909, and published in *Bulletin* No. 37, January, 1910, pp. 21 to 25.

A. SCOTT REID, London, Eng. (communication to the Secretary*) :—As a constructor of several glass mine-models, I have read with much interest the description of the model of the Montana-Tonopah mine-workings by Edmund D. North.

As an interchange of ideas and experience is always an advantage, and in view of the fact that such models are coming more and more into vogue, perhaps the following remarks on this subject may prove of interest to mining engineers generally and to Mr. North particularly.

In the model of the Waihi gold-mine, New Zealand, which I constructed, a dust-proof case is used. The top, bottom, front, and two ends are of glass; the back only is of wood, painted a dull white, against which the mine-workings show very distinctly. Each mine-level is represented by a horizontal sheet of glass, supported on metal runners fixed to the uprights at each end of the case, in a manner similar to that described by Mr. North. The corner uprights are strengthened by having a metal band screwed to the inside face of each, to which the metal runners or supports for the sheets of glass are screwed in turn. The reason for having this additional strength is that as the mine is developed in depth, and fresh levels are opened, the increasing weight of the glass sheets, added to the model, caused the unsupported wooden uprights to bend slightly, so that the glass sheets did not fit in with the desired nicety, and co-ordination was, to a considerable extent, lost. Strengthening the uprights in this manner is not important in models of mines in which only a few levels have been opened, or when the sheets of glass are small, but in the Waihi model there are 15 sheets of glass to be supported, and more to be added as development proceeds, and the weight is considerable.

* Received Feb. 25, 1910.

The glass sheets are 24 by 40 in. in area by 0.25 in. thick. Thick glass is used because thinner sheets of this large size sagged somewhat. The front only of the model is removable, and is held in place at the bottom by metal pegs fitting into holes in the base stretcher, as in Mr. North's model, and by key-locks at the top.

The mine-workings are traced on the glass from the plans in a manner similar to that described by Mr. North. Ordinary artist oil-colors are used, reduced to a workable consistency by diluting with "megilp" or turpentine; also a little prepared sugar of lead is added to hasten the drying. I have found a ruling-pen to be the best instrument with which to do the lettering on the glass; the other work is done with a small sable-hair brush.

The idea of using a different color for the drives and cross-cuts at each level is good, and must be of great advantage in many cases. In the Waihi model all the drives and cross-cuts at each level are drawn in black, and the reef is painted on in crimson, the walls being indicated by a thin vermilion line. The width of the reef is indicated by vermilion figures at the ends of the various cross-cuts through the reef and at other desired points. All figures, signs, and notes in red refer to the reef; all in black refer to levels, number of levels, the depth down the shaft, names of cross-cuts, etc., other colors being used to indicate geological features.

Another point of difference between Mr. North's model and those which I have constructed is that I use thin sheets of gelatine instead of glass to represent the vertical sections. This gelatine, which is made in sheets, 23 by 19 in. in size, is cut into strips just sufficiently wide to clear vertically the space between two levels, and when set in position the strips represent the standing reef between two levels. The sheets are placed in position along the reef on the glass, following the windings of the reef, and are held in place by means of small angle-pieces of the same material, which are fixed to the glass and to the vertical gelatine strips by means of transparent glue or cement. The strips of gelatine are, of course, sloped to correspond with the dip of the reef between levels, the term "vertical" being only approximate, since the gelatine strips will be vertical only when the reef is so. The gelatine sheet

is easily manipulated and cut with scissors, and, if held in a moderate heat, it can be bent to the desired curve, which it retains when cold. The angle-pieces are made by holding small oblong pieces of the gelatine against an electric lamp and folding them to the required angle. On these vertical gelatine strips the stopes and winzes are shown. As stoping proceeds, the gelatine is gradually covered with crimson paint until the whole of the ore between any two levels is taken out. When necessary to indicate the thickness of a reef between two levels, this is done by sticking on pieces of gelatine transversely to the strike of the reef, and painting on these pieces the cross-section of the reef. The vertical glass cross-sections in Mr. North's model serve this purpose, and, as he points out, at the same time act as supports to the horizontal glass sheets.

Winzes are shown by broad black lines drawn on the gelatine, and where these are sunk in ore a narrow strip of crimson paint is drawn down each side; these crimson lines are omitted when the winze is in country-rock or in unpayable quartz. The gelatine strip is added to, from winze to winze, as the stopes are extended longitudinally. Obviously there is no need to put in any gelatine where the reef is unpayable and will not be stoped.

The contour of the surface of the ground is indicated in a general manner by vertical strips of gelatine, radiating in all directions from the highest point to the boundary-lines of the mine. These strips are cut along the top edge to the required slope to represent the hill in which the upper workings of the mine are situated, and a green line about $\frac{1}{4}$ in. broad is painted along the top edge. As the ground slopes away the green line is continued on the gelatine on successively lower glass sheets.

Pillars of wood, $\frac{3}{16}$ by $\frac{3}{16}$ in. in cross-section, painted black, represent the hauling- and pumping-shafts, and $\frac{3}{16}$ in. square pillars represent filling-shafts.

The top and bottom glass sheets are ruled off into 2-in. (= 100-ft.) squares, lettered alphabetically along the top and bottom, and numbered along the ends. The boundary-lines are drawn on each level; and the bottom glass, instead of being ground, as in Mr. North's model, has strained over it a sheet of thin tracing-drawing paper, which is rather more opaque than ordinary tracing-paper, and diffuses the light from the electric

lamps underneath very satisfactorily. The model stands on supports 8 in. high, and in the space between the floor and the glass bottom of the case the electric lamps are placed. These lamps, six in number, are fixed in groups of two on three oblong wooden blocks which lie unfixed on the floor; the blocks measure 10 by 3.5 by 1 in., and are connected with each other by 18 in. of loose wire. The object in having the lights movable is that the whole six lights may be concentrated when desired, but normally they are spread out to give the best general light to the model.

The scale of the model is 50 ft. to 1 in. Two other models, similar in all respects to the Waihi model, except that they are 4 in. shorter, are necessary to contain the Waihi mine-workings. The total height of the model, from the floor to the top of the case, is 3 ft. 9 in.

The Limit of Fuel-Economy in the Iron Blast-Furnace.

BY N. M. LANGDON, MANCERLONA, MICH.

(Spokane Meeting, September, 1909.)

THE following corrections to the paper of Mr. Langdon (*Bulletin* No. 34, October, 1909, pp. 919 to 940), received after the publication of the paper in the *Bulletin*, will be incorporated in the paper as finally published in the forthcoming Vol. XL. of the *Transactions*, but are here presented for the information of members:

Page.

921. Table I., furnace M2, item 11. For "8801" read "0.8801."

922. Table II., furnace C, item 2, under gas. For "0.011 C" read "0.011 O."

Furnace G, item 13, under gas. For "5.074 air" read "3.074 air." Item 15, "4.269" should be "4.289."

Furnace H, item 2, under iron. For "0.04" read "0.01."

923. Table II., furnace J, item 1, under iron. For "0.95" read "0.93."

Furnace N2, item 6, under gas. For "0.66 CO₂" read "0.066 CO₂."

924. Table III., furnace C, item 17. For "379" read "397."

927. Table IV., furnace C, item 4. For "0.0124" read "0.0424."

Furnace G, item 15. For "4,060" read "4,066."

928. Line 2. Items 19 and 20 of heat-supply, should be items 20 and 21.

930. Line 3. Expunge remainder of paragraph after the word "supplied," and substitute the following: "As compared with the fusion-zone, the loss by radiation in C was 25.5 per cent. of the total (2,278 units) supplied to that zone, while in D it was 22.5 per cent. of the total heat (1,824 units) supplied to that zone. Finally, as compared with the reduction-zone, C lost by radiation 36.8 per cent. of the 1,580 units supplied to that zone,

while D lost 26.4 per cent. of the 1,557 units supplied. The comparison thus shows a saving in heat lost by radiation by D of 2.9 per cent. of the total heat supplied, 3 per cent. of the heat of the fusion-zone, and 10.4 per cent. of the heat of the reduction-zone."

Line 14. For "radiation of the heat" read "radiation relative to the heat."

936. Line 6. Expunge "(item 15, Table III)," and in line 7, after "gas," insert "(item 12, Table III)."

Line 19. For "553" read "552."

937. Line 18. For "2249" read "2240."

940. Expunge first paragraph under the heading "Conclusions," and replace by the following: "Upon careful consideration of the foregoing facts and figures, it will be evident that there are no more startling economies in fuel-consumption by the iron blast-furnace to be achieved by a further improvement in the air-blast, elimination of the nitrogen having been shown to be a detriment instead of a benefit."

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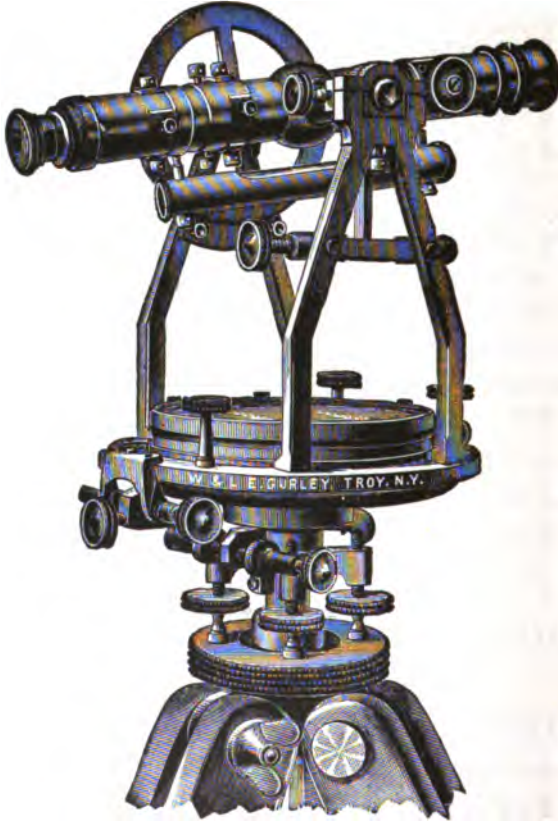
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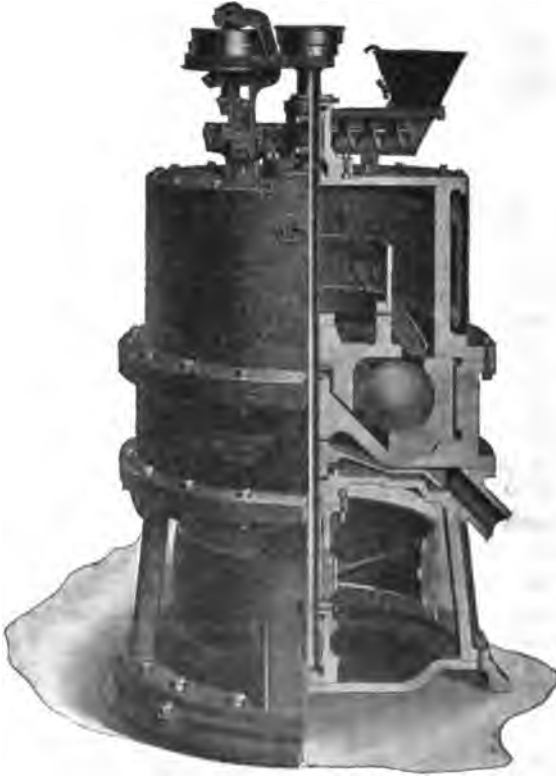
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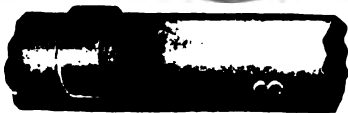
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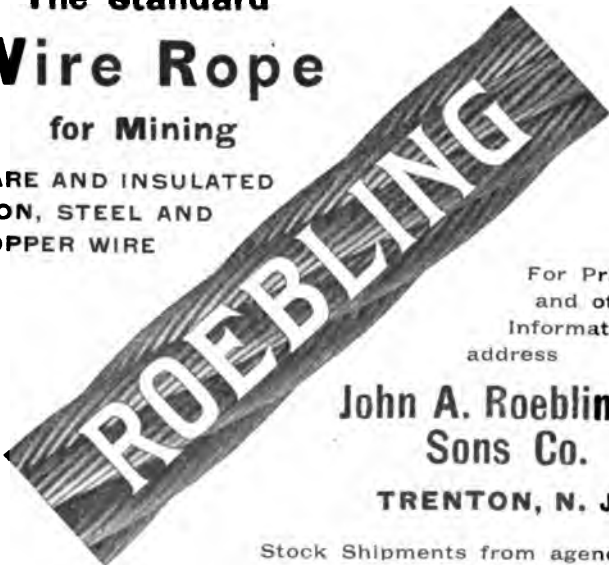
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SECTION I.—INSTITUTE ANNOUNCEMENTS.

This section contains announcements of general interest to the members of the Institute, but not always of sufficient permanent value to warrant republication in the volumes of the *Transactions*.

SECTION II.—TECHNICAL PAPERS AND DISCUSSIONS.

[The American Institute of Mining Engineers does not assume responsibility for any statement of fact or opinion advanced in its papers or discussions.]

A detailed list of the papers contained in this section is given in the Table of Contents. They have been so printed and arranged (blank pages being left when necessary) that they can be separately removed for classified filing, or other independent use.

A small stock of separate pamphlets, duplicating the technical papers given in Section II. of this Bulletin, is reserved for those who desire extra copies of any single paper.

Comments or criticisms upon all papers given in this section, whether private corrections of typographical or other errors or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.

All communications concerning the contents of this Bulletin should be addressed to Dr. Joseph Struthers, Assistant Secretary and Editor, 29 W. 39th St., New York, N. Y. (Telephone number 4600 Bryant).

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For the year ending February, 1911.

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* SECRETARY'S NOTE.—The Council is the professional body, having charge of the election of members, the holding of meetings (except business meetings), and the publication of papers, proceedings, etc. The Board of Directors is the body legally responsible for the business management of the Corporation, and is therefore, for convenience, composed of members residing in New York.

INSTITUTE ANNOUNCEMENTS.

Canal Zone Meeting.

The Canal Zone meeting of the Institute will be held, as announced, in November next. The steamer conveying the Institute party is scheduled to sail from New York, Oct. 28, or 29, 1910, and, returning, to arrive at New York about Nov. 25. The trip is to include stops at several interesting points in the West Indies.

The number of members and guests already "provisionally" announced exceeds largely the number that can be accommodated on the steamship or on the Isthmus; but, since some of those who have thus indicated their "probable intention" may change their minds, it is worth while for any member who may find it possible to take part in this excursion, to notify Dr. Joseph Struthers at this office, of his desire, so that arrangements may be made, if possible, for his accommodation.

Meetings of Other Societies.

American Institute of Electrical Engineers.—The Twenty-seventh Annual Convention of the American Institute of Electrical Engineers will be held at the Waumbek, Jefferson (White Mountains), N. H., Monday to Thursday, June 27, 28, 29, and 30, 1910. The Institute headquarters during the convention will be at the Waumbek. The convention sessions will be held in the hotel. The following papers are to be presented:

President's Address. Lewis B. Stillwell.

Headlight Test. By C. Francis Harding and A. N. Topping.

Light Standards. By Edward B. Rosa.

Modern Oil Switch. By A. R. Cheyney.

Disruptive Strength with Transient Voltages. By Charles P. Steinmetz and J. L. R. Hayden.

The Electric Strength of Air. By John B. Whitehead.

Vector Power in Alternating-Current Circuits. By Arthur E. Kennelly.

Determination of Transformer Regulation Under Load Conditions and Some Resulting Investigations. By Adolph Shane.

American Telegraph Engineering. Notes in History and Practice. By Wm. Maver and Donald McNicol.

Telephone Engineering Around the Golden Gate. By Arthur B. Smith.

Interaction of Fly-Wheels and Motors When Driving Roll Trains by Induction Motors. By F. G. Gasche.

Recent Progress in Exact Electrical Measurements. By Clayton H. Sharp and W. W. Crawford.

Electric Locomotive Design. By N. W. Storer and Eaton.

A Method of Determining the Adequacy of an Electric Railway System. By R. W. Harris.

Third Rail Construction. By Jesse H. Davis.

Power Economy in Electric Railway Operation—Coasting Clock Tests on the Manhattan Elevated Railway. By H. S. Putnam.

Wednesday evening at 6 o'clock there will be a dinner and discussion by the Sections Committee and Section delegates.

Thursday evening there will be a dinner followed by a discussion under the auspices of the Educational Committee.

The entertainment features include a reception and dance at the Waumbek; an excursion to Mount Washington; golf and tennis tournaments, and other outdoor sports.

The American Society of Mechanical Engineers.—The American Society of Mechanical Engineers will hold a joint meeting with the Institution of Mechanical Engineers in England, July 25–30, 1910. The Committee of the Society in charge of arrangements consists of Ambrose Swasey, *Chairman*; Charles Whiting Baker, *Vice-Chairman*; W. F. M. Goss, Geo. M. Brill, John R. Freeman, and George Westinghouse, Wm. H. Wiley, F. R. Hutton, Willis E. Hall, Calvin W. Rice, *ex officio*.

The program consists of an official reception upon arrival in Birmingham on Monday, July 25; a reception to the officers and members of the Society and to the council and members of the Institution of Mechanical Engineers by the Lord Mayor of Birmingham and Members of the Local Committee on Tuesday, July 26, followed by luncheon in the Town Hall, and visits to Stratford-on-Avon, Worcester, Gloucester, or Bournville, and local works in the afternoon. In the evening there will be a garden-fete. On Wednesday morning there will be reading and discussion of papers, followed by luncheon in the Town Hall, with visits to the University and local works in the afternoon and a reception in the Council House on invitation

of the Lord Mayor in the evening. The morning of Thursday, July 28, will be spent in visits to Coventry and Rugby, Warwick, Leamington, Kenilworth, or Lichfield. On the afternoon of the same day the party will proceed to London, where in the evening a conversazione will be held at the Institution. On Friday, papers will be presented in the morning, garden-parties will be held at private houses in the afternoon, and in the evening there will be a dinner in the Connaught Rooms, Freemason's Hall, given by the Institution. The program will conclude on Saturday with an excursion by rail and river to Windsor and Henley and a reception at the Garden Club in the Japan-British exhibition at the White City.

Papers will be contributed by the Society on the Electrification of Railways and Roundhouse Practice, and there will be a topical discussion on High-Speed Tools.

Society for the Promotion of Engineering Education.—The annual meeting of the Society for the Promotion of Engineering Education will be held at Madison, Wis., on Thursday, Friday and Saturday, June 23, 24 and 25. An attractive program has been arranged for the meeting. Among the most important items are the reports of the Committees on Entrance Requirements and Engineering Mathematics, which will be presented for final action. Copies of the reports in full will be distributed to the membership some weeks in advance of the meeting. Technical Education Abroad, Inspection Trips for Technical Students, Efficiency in Technical Education, and other topics will be presented for discussion. Full information regarding the meeting and the general work of the Society can be secured from Prof. H. H. Norris, Cornell University, Ithaca, N. Y.

Members of the American Institute of Mining Engineers are cordially invited to attend these meetings.

How to Use the "Transactions" of the Institute.

Buy a copy of the Complete Analytical and Alphabetical Index of Volumes I. to XXXV., inclusive.

If you own a full set of the *Transactions*, this Index will make the whole of it instantaneously available without detailed research into each volume separately.

If you do not own such a set, this Index will be even more valuable, for it will show you what particular papers you need to know more about, and perhaps to study. Thus, any person possessing this Index can ascertain at once what has been published in the *Transactions* on a given question, and can learn, by writing to the Secretary, what is its nature, whether it is still to be had in pamphlet form, where it can be consulted in a public library, at what cost it can be copied by hand, etc., etc.

In short, to those who own complete sets of the *Transactions*, this Index will be a great convenience; but to those who do not, it will be a professional necessity.

This volume is an octavo of 706 pages, containing more than 60,000 entries, duly classified with sub-headings, and including abundant cross-references. It has not been stereotyped, and the edition is limited to 1,600 copies. The price of the volume, bound in cloth, is \$5, and bound in half-morocco to match the *Transactions*, \$6. The delivery charges will be paid by the Institute on receipt of the above price.

Hydrographic Chart.

Owing to the great value to hydrographers of the chart contained in the paper, *A Graphic Solution of Kutter's Formula*, by L. I. Hewes and Joseph W. Roe (*Bulletin No. 29, May, 1909, p. 454*), a special edition for office or field use has been printed on durable cloth. Copies of this separate chart may be obtained, at a cost of 50 cents each, on application to the office of the Secretary of the Institute.

LIBRARY.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

AMERICAN INSTITUTE OF MINING ENGINEERS.

UNITED ENGINEERING SOCIETY.

The libraries of the above-named Societies are open from 9 A.M. to 9 P.M. on all week-days, except holidays, from September 1 to June 30, and from 9 A.M. to 6 P.M. during July and August.

RULES.

For the protection and convenience of members, the following rules have been adopted :

The Secretary of each Society will, upon application, issue to any member of his Society in good standing a personal, non-transferable card, entitling him to the use of the Libraries in the alcoves of the Reading-Room. This card must be signed by the person receiving it, and surrendered at the desk at the time of its presentation. At every visit he must identify himself by signing his name in the registry.

The first two alcoves are free to all; and admission to the inside alcoves is given only upon proper introduction.

The above rules apply to all persons except officers of the three Societies, personally known as such to the librarians.

The librarians are not permitted to lend to any person any catalogued pamphlet or volume, unless authorized in writing so to do by the Secretary or Chairman of the Library Committee of the Society to which the pamphlet or volume belongs.

Any person discovering a mutilation or defect in any book of the libraries is requested to report it to the librarian on duty.

Library Accessions.

May 1 to June 1, 1910.

[Copies of the list of additions to the Libraries of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers can be obtained on application to the Secretary of the American Institute of Mining Engineers.]

AMALGAMATED SOCIETY OF ENGINEERS. Annual Report, 59th. London, 1910. (Gift.)

AMERICAN INSTITUTE OF ARCHITECTS. Relations of Railways to City Development. Paper read Dec. 16, 1909. Washington, 1909. (Exchange.)

AMERICAN MUSEUM OF NATURAL HISTORY. Annual Report of the Trustees, 41st, 1909. New York, 1910. (Exchange.)

ANALYSIS OF ALUMINUM AND ITS COMMERCIAL ALLOYS. Compiled by E. Blough. Pittsburg, 1910. (Gift of Aluminum Company of America.)

ANALYSIS OF SILICATE AND CARBONATE ROCKS. (Revision of Bulletin 305.) (Bulletin No. 422, U. S. Geological Survey.) By W. F. Hillebrand. Washington, 1910. (Exchange.)

BIBLIOGRAPHIE DER DEUTSCHEN ZEITSCHRIFTEN-LITERATUR. Vol. 24-A. Leipzig, 1910. (Purchase.)

BOSTON PUBLIC LIBRARY. Annual Report of the Trustees, 58th, 1909-1910. Boston, 1910. (Exchange.)

BRITISH GUIANA. LANDS AND MINES DEPARTMENT. Report, 1908-1909. Georgetown, 1910. (Gift of Commissioner of Lands and Mines.)

CANADA. MINES DEPARTMENT. Annual Report of the Division of Mineral Resources and Statistics on the Mineral Production of Canada, 1907-1908. Ottawa, 1910. (Exchange.)

CATALOGUE OF NEARCTIC SPIDERS. By N. Banks. (Smithsonian Institution. U. S. National Museum. Bulletin No. 72.) Washington, 1910. (Exchange.)

COMPLETE MINERAL CATALOGUE. Ed. 12. By W. M. Foote. Philadelphia, Foote Mineral Company, 1909. (Gift of Author.)

CONTRIBUTIONS TO ECONOMIC GEOLOGY (Advance chapter from), 1909. Pt. I.—Metals and Non-Metals, except Fuels. (Bulletin No. 430-B, U. S. Geological Survey.) Washington, 1910. (Exchange.)

CORROSION AND PRESERVATION OF IRON AND STEEL. By A. S. Cushman and H. A. Gardner. New York, McGraw-Hill Book Co., 1910. Price, \$4.00 net. (Gift of H. A. Gardner.)

[SECRETARY'S NOTE.—This book, prepared by Dr. Cushman, Chemist of the U. S. Department of Agriculture, and Mr. Gardner, Director of the Scientific Section of the Paint Manufacturers Association of the U. S., contains, as its authorship would lead us to expect, a summary of both theoretical and practical inquiry. Though frankly supporting the electrolytic hypothesis of corrosion, it gives a fair statement of other hypotheses, together with many experimental data and discussions, and an extensive bibliography, which must be highly valuable to all students of the subject. In successive chapters, it treats the problem of corrosion and preservation; the theory of solution; the theories of corrosion; the application of the electrolytic theory; the inhibition and stimulation of corrosion; the technical protection of iron and steel; the relation of pigments to the corrosion of iron; recent field-tests on protective coatings for iron and steel; paints for

various purposes; the testing and design of protective paints; the properties of pigments; and the properties of paint-vehicles. Appendix A presents in full the important discussion on the corrosion of the water-jackets of copper blast-furnaces contained in the *Transactions* of this Institute (vol. xxxviii., 877 to 884; xxxix., 806 to 817). The book is appropriately dedicated "to the memory of Charles B. Dudley, who, during a life of splendid service, was always ready to encourage investigation, and who earnestly believed that there was something new to be learned in every branch of knowledge." Indeed, Dr. Dudley's contributions to this particular branch of knowledge were by no means insignificant.—R. W. R.]

CYANIDE HANDBOOK. By J. E. Clennell. New York, McGraw-Hill Book Co., 1910. Price, \$5.00 net. (Gift of Publishers.)

[SECRETARY'S NOTE.—The literature of the cyanide process has attained in the last ten years a large volume; but this new treatise seems likely to meet a special need, by its full treatment of certain aspects of the subject and its comprehensive digest of much information otherwise to be gained only by search through many books. Beginning with the general history and description of the process, it treats in successive parts the chemical reactions involved; the preparatory treatment of ore; the action of the solution; the subsequent precipitation and smelting; special modifications of the method; assays; analyses and metallurgical tests. Under each of these headings abundant details are given, and the theory is clearly set forth. The volume has about 580 pages, is beautifully printed, and ends with an excellent alphabetical index, which, together with its full table of contents, will make it most convenient to students and practitioners alike.—R. W. R.]

DEUTSCHE CHEMISCHE GESELLSCHAFT. Mitglieder-Verzeichnis, 1910. N. p., n. d. (Exchange.)

GEOLOGY AND OIL RESOURCES OF THE COALINGA DISTRICT, CALIFORNIA. By Ralph Arnold and Robert Anderson. (Bulletin No. 398, U. S. Geological Survey.) Washington, 1910. (Exchange.)

GOLDFIELD CONSOLIDATED MINES COMPANY. Annual Report, 2d and 3d. Goldfield, 1908–1909. (Gift of Company.)

— Annoucement, Nov. 21, 1906. Goldfield, 1906. (Gift of Company.)

ILLINOIS. BUREAU OF LABOR STATISTICS. Biennial Report, 15th, 1908. Springfield, 1910. (Exchange.)

ILLINOIS. STATE GEOLOGICAL SURVEY. Yearbook for 1908. (Bulletin No. 14.) Urbana, 1909. (Exchange.)

JAARBOEK VAN HET MIJNWEZEN IN NEDERLANDSCH OOST-INDIE, 1908. Batavia, 1910. (Exchange.)

JOHNS HOPKINS UNIVERSITY. Register, 1909–1910. Baltimore, 1910. (Exchange.)

KAISERLICHEN STATISTISCHEN AMTE. Statistisches Jahrbuch für das Deutsche Reich, 1909. Berlin, 1909. (Purchase.)

MICHIGAN. LABOR DEPARTMENT. Annual Report, 1st. Lansing, 1910. (Exchange.)

MICHIGAN STATE SALT INSPECTOR. Annual Report, 33–36, 39, 40, 41, 1901–1904, 1907, 1908, 1909. Bay City, 1901–1904, 1907, 1908, 1909. (Gift of State Salt Inspector.)

MINERAL RESOURCES OF THE NABESNA-WHITE RIVER DISTRICT, ALASKA. (Bulletin No. 417, U. S. Geological Survey.) By F. H. Moffit and Adolph Knopf. Washington, 1910. (Exchange.)

MODERN ASSAYING. By J. R. Smith. Edited by F. W. Braun. Philadelphia, J. B. Lippincott Company, 1910. (Gift of Publishers.)

[**SECRETARY'S NOTE.**—The title of this little book (145 pp., 12mo.) is misleading; but the Preface disclaims frankly any pretension to comprehensive or thorough character. The book is intended to serve beginners, and one of its services will doubtless be to lead them to go further, under the guidance of larger manuals. It describes with exceeding brevity the preparation of samples; the fire-assay for gold and silver; lead and antimony; several kinds of humid and volumetric assaying; electrolytic assaying; distillation and retorting, etc.; and gives practical directions for the handling of reagents and apparatus, together with illustrations, chiefly of the laboratory appliances manufactured by the Braun Corporation at Los Angeles. There is also a somewhat irrelevant chapter on "oxone" and its use in respirators, furnished by the manufacturers, the Roessler & Hasslacher Chemical Co., of New York.—R. W. R.]

NATAL. Report on the Mines and Mineral Resources of Natal (other than Coal). By F. H. Hatch. Published by order of the Natal Government. London, R. Clay & Sons, 1910. (Gift of F. H. Hatch.)

NEW YORK STATE. Advisory Board of Consulting Engineers. Report to the Governor, 1909. Albany, 1910. (Gift of State Engineer and Surveyor's Office.)

NEW YORK STATE. Water-Supply Commission. Annual Report, 5th. Albany, 1910. (Gift of N. Y. State Water-Supply Commission.) Pt. I—Municipal Water-Supply; Pt. 2—River Improvement and Flood Prevention; Pt. 3—Water Storage and Power Development.

NORTH BROKEN HILL MINING COMPANY. Report and Statement of Accounts for Half-Year ended June 30 and Dec. 31, 1908, and June 30 and Dec. 31, 1909. Broken Hill, 1908–1909. (Gift of Company.)

OKLAHOMA. CHIEF INSPECTOR OF MINES. Annual Report, 1st, 1907–1908. McAlester, 1908. (Gift of Chief Inspector of Mines.)

PANAMA CANAL. Isthmian Canal Commission, 1910. N. p., n. d. (Exchange.)

PETER COOPER. By Dr. R. W. Raymond. Boston-New York, Houghton, Mifflin & Co., 1901). (Gift of Dr. Raymond.)

PRELIMINARY REPORT ON THE MCKITTRICK-SUNSET OIL REGION, KERN AND SAN LUIS OBISPO COUNTIES, CALIFORNIA. (Bulletin No. 406, U. S. Geological Survey.) By R. Arnold and H. R. Johnson. Washington, 1910. (Exchange.)

PROGRESS OF THE MINERAL INDUSTRY OF TASMANIA, FOR THE QUARTER ENDING DEC. 31, 1909. Tasmania, 1910. (Gift.)

PURCHASE OF COAL BY THE GOVERNMENT UNDER SPECIFICATIONS, WITH ANALYSES OF COAL DELIVERED FOR THE FISCAL YEAR 1908–1909. (Bulletin No. 428, U. S. Geological Survey.) By G. S. Pope. Washington, 1910. (Exchange.)

ROYAL INSTITUTE OF BRITISH ARCHITECTS. Charter, Supplemental Charter, and revised By-Laws, 1910. London, 1910. (Exchange.)

SOCIETA TOSCANA DI SCIENZE NATURALI. Atti. Vol. 25. Pisa, 1909. (Exchange.)

SURFACE WATER-SUPPLY OF COLORADO RIVER DRAINAGE ABOVE YUMA, 1906. (Water-Supply Paper No. 211, U. S. Geological Survey.) Washington, 1908. (Exchange.)

- SURFACE WATER-SUPPLY OF THE UNITED STATES, 1907-1908. Pt. I.—North Atlantic Coast. (Water-Supply Paper No. 241, U. S. Geological Survey.) By H. K. Barrows and R. H. Bolster.
- Pt. III.—Ohio River Basin. (Water-Supply Paper No. 243, U. S. Geological Survey.) Washington, 1910. (Exchange.)
- ÜBER DIE ZUSAMMENSETZUNG DER FINNISCHEN EISENERZE, KALKSTEINE EISENHÜTTENPRODUKTE UND IHRER NEBENPRODUKTE. By G. A. Aartovaara. Helsinki, 1910. (Gift.)
- U. S. COAST AND GEODETIC SURVEY. Supplementary Investigation in 1909 of the Figure of the Earth and Isostasy. By J. F. Hayford. Washington, 1910. (Exchange.)
- UNITED STATES GEOLOGICAL SURVEY: ITS ORIGIN, DEVELOPMENT, ORGANIZATION, AND OPERATIONS. (Bulletin No. 227, U. S. Geological Survey.) Washington, 1904. (Exchange.)
- UTAH CONSERVATION COMMISSION. Preliminary Report, 1909. Salt Lake City, 1909. (Gift of Utah Conservation Commission.)
- UTAH STATE ENGINEER. Biennial Report, 4th-6th, 1903-1908. Salt Lake City, 1905, 1907, 1909. (Gift of Utah State Engineer.)
- Special Instructions to Watermasters regarding measurements of water, to secure a just distribution of the same, Dec., 1898. (Gift of Utah State Engineer.)
- VEREIN DEUTSCHER EISENHÜTTENLEUTE. Mitgliederverzeichnis, 1910. Düsseldorf, 1910. (Exchange.)
- WALLAROO & MOONTA MINING & SMELTING COMPANY, LTD. Reports and Statements of Accounts. 20th Annual Report, 1909. Adelaide, 1909. (Gift of Company.)
- WESTERN BLUE BOOK AND BUYERS' REFERENCE, 1908, 1909. Chicago, A. Winch, 1908-1909. (Gift of Publisher.)

TRADE CATALOGUES.

- AMERICAN GRÖNDALL KJELLIN Co., New York, N. Y. Concentration and briquetting of iron-ores. 22 pages.
- DENVER FIRE CLAY Co., Denver, Colo. Assayers' and Chemists' supplies and scientific apparatus. 424 pages.
- DILLON BOX IRON WORKS Co., Denver, Colo. Data sheet No. 49. Contractor's electric hoist. 2 pages.
- FOOTE MINERAL Co., Philadelphia, Pa. Prospectus of 12th revised and enlarged edition of the Complete Mineral Catalog. 37 pages.
- GENERAL ELECTRIC Co., Schenectady, N. Y. Price list applying to 1909 electrical supply catalogue. 148 pages.
- HOLMAN BROS., Camborne, Cornwall (England). Catalogue of ore-dressing machinery; concentrating tables; mill for wet grinding, etc. 30 pages.
- INGERSOLL-RAND Co., New York, N. Y. Booklet on the diamondless core drill. 19 pages.
- JEFFREY MANUFACTURING Co., Columbus, O. Booklet No. 38. Jeffrey conveying machinery. 24 pages.
- LEHIGH CAR, WHEEL & AXLE WORKS, Catasauqua, Pa. "Fuller" face-hardened sprocket wheels, traction wheels, chilled conveyor bearings, and gudgeons. 20 pages.
- H. MORIN, Paris, France. Precision instruments for all purposes. 96 pages.
- NORTH AMERICAN ASBESTOS Co., Kansas City, Mo. Prospectus showing finances and standing of North American Asbestos Co. 30 pages.

- T. H. PROSKE, Denver, Colo. "Ajax" drill sharpener and drill sharpening machines. 16 pages.
- STROMBERG-CARLSON TELEPHONE MFG. Co., Chicago, Ill. Bulletin No. 1000. No. 890 type mine telephone. 6 pages.
- STROMBERG-CARLSON TELEPHONE Co., Rochester, N. Y. How to build a rural telephone line. 24 pages.
- TAYLOR INSTRUMENT Co., Rochester, N. Y. *Tycos*—March and April, 1910, issues; a publication in the interest of all thermometer and instrument users. 24 pages.

United Engineering Society Library.

- A. L. A. PORTRAIT INDEX, 1906. Washington, 1906. (Purchase.)
- ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE. Year 38—date. Berlin, 1910—date. (Purchase.)
- IOWA. BOARD OF RAILROAD COMMISSIONERS. Annual Report, 27th–31st, 1904–1908. Des Moines, 1905–1909. (Gift of Iowa Railroad Commissioners.)
- JOURNAL FÜR GASBELEUCHTUNG: GENERAL REGISTER ZUM JAHRGANG, 32–46 (1889–1903). München, 1905. (Purchase.)
- NEBRASKA. STATE RAILWAY COMMISSION. Annual Report, 1st and 2d. Lincoln, 1908, 1909. (Gift of Nebraska State Railway Commission.)
- NEVADA. STATE CONTROLLER. Annual Report, 1905–1909. Carson City, 1906–1910. (Gift of Nevada State Controller.)
- NEW HAMPSHIRE. RAILROAD COMMISSION. Annual Report, 65th, 1909. Manchester, 1910. (Gift of New Hampshire Railroad Commissioners.)
- OHIO. RAILROAD COMMISSION. Report, 1st, 3d, and 4th. Springfield, 1906, 1908, 1910. (Gift of Ohio Railroad Commission.)
- PRACTICAL INSTRUCTIONS RELATING TO THE CONSTRUCTION AND USE OF THE STEAM ENGINE INDICATOR. Boston, Crosby Steam Gage & Valve Company, 1910. (Gift of Alfred B. Carhart.)

GIFT OF AMERICAN GAS INSTITUTE.

- AMERICAN GAS LIGHT JOURNAL. Vols. 56–67. New York, 1892–1897.
- ASSOCIATION OF GAS ENGINEERS AND MANAGERS, UNITED KINGDOM. Reports of Proceedings, 1887–1897. London, 1888–1898.
- BRITISH ASSOCIATION OF GAS MANAGERS. Report of Proceedings, 1876–1879. (Title changed to Gas Institute in 1881.)
- CONGRÈS INTERNATIONAL DE L'INDUSTRIE DE GAZ. Compte rendu des Travaux Publié par les Soins de la Société Technique de L'Industrie de Gaz en France. 15th–28th, 30th–36th Congresses. Paris, 1888–1901, 1903–1909.
- Assemblée Générale Rapports Annexes. Paris, 1900.
- DEUTSCHER VEREIN VON GAS UND WASSERFACHMÄNNERN. Verhandlungen, 1903–1907. München, 1903–1907.
- GAS INSTITUTE. Transactions, 1884–1885. London, 1884–1885. (Early title to 1881, British Association of Gas Managers.)
- INCORPORATED GAS INSTITUTE. Transactions, 1896, 1897, 1899, 1900. London, 1896–1897, 1899–1900. (Merged in 1902 to form Institution of Gas Engineers.)
- INCORPORATED INSTITUTION OF GAS ENGINEERS. Transactions. Vols. 1–6, 8–12. London, 1892–1903. (Merged with Gas Institute in 1902 to form Institution of Gas Engineers.)
- INSTITUTION OF GAS ENGINEERS. Transactions, 1903–1908. London, 1903–1908.

JOURNAL OF GAS LIGHTING, WATER SUPPLY, AND SANITARY IMPROVEMENT.

Vols. 23-50 ; 51 (except Jan. 3, May 8, June 26, and index) ; 52 except July 17, 24, 31, and index) ; 53-56 (except indexes) ; 58 (except index) ; 59 (except all of Jan., Feb. 2 and 16, all of March, April 12, May 3 and 31, and index) ; 60 (except Oct. 11, Nov. 1, and index) ; 61 (except June 13, 20, 27, and index) ; 64-79 ; 80 (except Oct. 14) ; 81 (except March 24) ; 82 ; 83 (except Sept. 1) ; 84 (except Oct. 27) ; 85-87 ; 89 ; 90 (except index) ; 91 (except July 11-Aug. 8, Aug. 22, Dec. 12) ; 93 (except Jan. 30, Feb. 6) ; 94-95 ; 96 (except Nov. 6) ; 97-98 (except indexes) ; 100, No. 2326. London, 1874-1907.

PROGRESSIVE AGE. Vols. 9-14 (6 vols. in 3). New York, 1891-1896.

MEMBERSHIP.

NEW MEMBERS.

The following list comprises the names of those persons elected as members who accepted election during the month of May, 1910:

Members.

Gilmour E. Brown,	Applegarth, Ballock, Scotland.
Mel C. Butler,	Fairfax, Wash.
Dean S. Calland,	Pachuca, Hidalgo, Mex.
R. C. Crawford,	Pittsburg, Pa.
Justin S. De Lury,	Moscow, Idaho.
James S. Douglas,	Douglas, Ariz.
David M. Folsom,	Stanford University, Cal.
George T. Haldeman,	Pittsburg, Pa.
Edmund C. Harder,	Washington, D. C.
Thomas S. Harrison,	Wiley, Wyo.
Richard Kleesattel,	Seattle, Wash.
Frank C. Laurie,	Mexico City, Mex.
David Lemmon,	Pioche, Nev.
Grenville Lewis,	Pineville, Ky.
David S. Longacre,	Dragon, Utah.
Harry B. Meller,	Pittsburg, Pa.
Charles G. Osborne,	South Chicago, Ill.
Charles E. Phoenix,	Bellingham, Wash.
Edward W. Ralph,	Kimberly, Nev.
Francis C. Richard,	Carlton, Victoria, Australia.
Charles H. Smith,	Baltimore, Md.
Stephen Taber,	University, Va.
U. Tsukakoshi,	Douglas, Ariz.
John Tyssowski,	Washington, D. C.
Robert B. Woodworth,	Pittsburg, Pa.
Arthur Yates,	Lebong Soelit, Sumatra, Dutch East Indies.

Associate.

John S. Piper,	Lawrenceville, Ill.
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CANDIDATES FOR MEMBERSHIP.

The following persons have been proposed for election as members of the Institute during the month of May, 1910. Their names are published for the information of members and associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or un-

favorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Council, which has the power of final election.

Life Member.

Frank Merton Warren, Minneapolis, Minn.

Members.

Robert L. Baillie,	Detroit, Mich.
Homer Frick Braddock,	Mt. Pleasant, Pa.
Melvin P. Dalton,	Poza, Sonora, Mexico.
John Daniell,	Laurium, Mich.
Harold P. Davis,	New York, N. Y.
Walter Hooker,	London, England.
Takeshi Kawamura,	Osaruzawa, Akita, Japan.
Junjiro Kobuse,	Kosaka, Akita-Ken, Japan.
Montrose L. Lee,	Oxford Furnace, N. J.
Charles A. Mitke,	Dawson, N. M.
Howard W. Morgan,	Milwaukee, Wis.
Albert Francis Plock,	Mayville, Wis.

Associates.

William Edwards Manning, Youngstown, Ohio.
Theodore Sternfeld, New York, N. Y.

CHANGES OF ADDRESS OF MEMBERS.

The following changes of address of members have been received at the Secretary's office during the month of May, 1910. This list, together with the lists published in *Bulletin* Nos. 38, 39, 40, and 41, therefore, supplements the annual list of members corrected to Jan. 1, 1910, and brings it up to the date of June 1, 1910. The names of members who have accepted election during the month (new members) are printed in *italics*.

ABADIE, EMIL R.....	P. O. Box 188, Bakersfield, Cal.
ADAMS, ARTHUR K.....	Spencer, Mass.
ATKINSON, WALLACE L.....	411 Howard Ave., N., Seattle, Wash.
BAKER, DAVID.....	1011 Chestnut St., Philadelphia, Pa.
BARBER, GEORGE M., Engr., Schloss Bros., Colombian Synd., Ltd.,	
	London, England.
BLAIR, ALLEN F., Care Blair, Wakeling & Rice, Mutual Life Bldg.,	
	Seattle, Wash.

- BRILL, PAUL K., Cia. Minera la Victoria y Tapada,
Apartado 47, Oaxaca, Oax., Mexico.
- BRITT, RICHARD H.....P. O. Box 55, Rockland, Me.
- BROMLY, ALFRED H., Care Taylor & Howat, Apartado 232, Mexico City, Mexico.
- *Brown, Gilmour E., Min. Engr.....Applegarth, Balloch, Scotland. '10.
- BUNKER, CHARLES E., Care Mrs. E. J. Culbert.....Amador City, Cal.
- BURRALL, FREDERICK P., Care U. S. & Mexican Trust Co., Singer Bldg.,
New York, N. Y.
- *Butler, Mel C., Coal Mine Supt., Care Tacoma Smelting Co., Fairfax, Wash. '10.
- CALDWELL, FOREST B.....Woodland, Cal.
- *Culland, Dean S., Asst. to Director, Cia. de Real del Monte y Pachuca,
Pachuca, Hgo., Mexico. '10.
- CARPENTER, EDWIN E.....111 No. Franklin St., Syracuse, N. Y.
- CAYPLESS, WILLIS S., Guanajuato R. & M. Co., Apartado 55, Guanajuato, Mexico.
- CHOUTEAU, PIERRE.....1000-3 National Bank Bldg., St. Louis, Mo.
- CLARKE, ROY H.....423 Rookery Bldg., Spokane, Wash.
- COLLINGS, BURTON I., Southern Rhodesia Mining Synd., Ltd.,
P. O. Box 80, Salisbury, Rhodesia, So. Africa.
- COX, WILLIAM J.....304 Boston Bldg., Denver, Colo.
- CROPPER, CECIL H.....The Oaks, Helsby, Cheshire, England.
- CRAUFURD, ALEXANDER J. F., Care Statehood Mines Co.....Hillsboro, N. M.
- *Crawford, R. C., Mine Operator, Prest., Electric Mfg. & Power Co. of S. C.,
Pittsburg, Pa. '10.
- CUMINGS, W. L.....316 North High St., Bethlehem, Pa.
- DAMON, GEORGE G.....Care P. E. Damon, Boone, Iowa.
- DAY, ARTHUR M.....General Delivery, Butte, Mont.
- *De Lury, Justin S., Asst. Prof. of Geol., Univ. of Idaho, Moscow, Idaho. '10.
- DENNIS, WILLIAM B., Vice-Prest. and Mgr., Carlton & Coast R. R. Co.,
Carlton, Ore.
- DICK-CLELAND, A. F.....Apartado 157, Guadalajara, Jal., Mexico.
- *Douglas, James S., Miner.....Douglas, Ariz. '10.
- DOVETON, GODFREY D., Care Spurr & Cox, Inc., Chamber of Commerce Bldg.,
El Paso, Texas.
- EILERS, KARL.....Sea Cliff, L. I., N. Y.
- EMANUEL, LOUIS V.....Newfoundland, N. J.
- ENGELHARDT, ERNEST C.....2705 Gilpin St., Denver, Colo.
- EWING, HARRY E.....Maybeury, W. Va.
- FLINN, FREDERICK B.....P. O. Box 91, Newark, N. J.
- *Folsom, David M., Min. Engr.....Stanford University, Cal. '10.
- FRASER, ALEXANDER J., Care La Frontera Mining Co.,
Old Glory, via Tucson, Ariz.
- GLOVEB, GEORGE H., Jr., Eastern Sales Agt., Ralston Steel Car Co.,
2 Rector St., New York, N. Y.
- *Haldeman, George T., Instructor in Mining, School of Mines,
Univ. of Pittsburg, Pittsburg, Pa. '10.
- HALL, GEORGE, Mines et Usines de Pontegrando,
Pontegrando di Bannio, Novara, Italy.
- *Harder, Edmund C., Min. Geol., U. S. Geol. Survey, Washington, D. C. '10.
- *Harrison, Thomas S., Min. Engr.....Wiley, Wyo. '10.
- HAWKINS, JOHN T.....P. O. Box 563, Colorado Springs, Colo.
- HEATHCOTE, CHARLES F., Care Institute of Mining and Metallurgy,
Salisbury House, London, E. C., England.

HELLMANN, FREDERICK, Care Leggett & Hellmann,

25 Broad St., New York, N. Y.

HOLLIS, R. W.....Silverton, Colo.

HOLLISTER, JOHN J.....Gaviota, Cal.

HOOPER, GEORGE H.....134 West End Ave., Somerville, N. J.

JENKS, ARTHUR W.....2231 Cedar St., Berkeley, Cal.

JENNEY, WALTER P.....3 Grant Place, Washington, D. C.

JOHNS, J. HARRY, Care H. Trembath,

28 North Parade, Penzance, Cornwall, England.

JONES, CHARLES H.....P. O. Box 163, Broken Hill, N. S. W., Australia.

KAMIYAMA, TATSUZO.....71 Wakamatsucho, Ushigome, Tokyo, Japan.

KAWAI, YASUSHIRO.....Nishimachi, Fukuyama, Bingo, Japan.

*Kleesattel, Richard, Min. Engr.....710 Alaska Bldg., Seattle, Wash. '10.

LANGLEY, SETH S.....1617 Central Ave., Alameda, Cal.

*Laurie, Frank C., Oil Geol. & Supt., Care S. Pearson & Son, Ltd., O. F. D.,

Apartado 113 Bis, Mexico City, Mexico. '10.

LEFEVRE, HENRY F.....71 Broadway, New York, N. Y.

LEGGETT, THOMAS H, Care Leggett & Hellmann, 25 Broad St., New York, N. Y.

*Lemmon, David, Mining Supt.....Pioche, Nev. '10.

*Lewis, Grenville, Supt., Straight Creek Coal & Coke Co.,

Box 217, Pineville, Ky. '10.

LITCHMAN, HAROLD B.....10 High St., Marblehead, Mass.

*Longacre, David S., Civ. & Min. Engr.....Dragon, Utah. '10.

MCCOLLOM, CHARLES R.....121 So. Euclid Ave., Pasadena, Cal.

McEWEN, ATHOLL F.....709 Torrey Bldg., Duluth, Minn.

MACDONALD, ARTHUR C.....54 New Broad St., London, E. C., England.

MACDONALD, CHARLES.....Room 103, 26 Exchange Pl., New York, N. Y.

MACFARLANE, RIENZI W.....Apartado 102, Parral, Chih., Mexico.

MATTHIESSEN, F. W.....1227 Ninth St., La Salle, Ill.

*Meller, Harry B., Instructor in Mining, Univ. of Pittsburg, Pittsburg, Pa. '10.

MENTZEL, CHARLES.....29 Broadway, New York, N. Y.

MOORE, ROBERT MCL.....348 Miller St., North Sydney, N. S. W., Australia.

MURPHY, THOMAS D....926 Webster St., New Orleans, La.

MUSGRAVE, ROBERT, Care The Exploration Co. of Eng. & Mex.,

523 Mutual Life Bldg., Mexico City, Mexico.

NORTON, EDWARD G.....Brinkley, Ark.

*Osborne, Charles G., Met., Illinois Steel Co., South Works, So. Chicago, Ill. '10.

PALSGROVE, HARRY G.....Dolores Mines Co., Madera, Chih., Mexico.

PERKINS, WALTER G., Met. Engr.....62 London Wall, London, E. C., England.

PERKS, HARRY B.....419 Board of Trade Bldg., Portland, Ore.

*Phoenix, Charles E., Civ. Engr., U. S. Deputy Mineral Surveyor,

White House Hotel, Bellingham, Wash. '10.

†Piper, John S., Master Mechanic, Indian Refining Co....Lawrenceville, Ill. '10.

PRINGLE, ROBERT W...Friars House, 40 New Broad St., London, E. C., England.

PUCKETTE, STEPHEN E.....Black Mountain Coal Land Co., Bristol, Tenn.

PYNE, FRANCIS R.....1145 Mary St., Elizabeth, N. J.

*Ralph, Edward W., Mine Supt., Care Boston-Ely Min. Co., Kimberley, Nev. '10.

REECE, PHILIP P.....Cortez, Nev.

REEVES, THOMAS V.....North Star Mines Co., Grass Valley, Cal.

REHW, JAMES W.....West Coast Co., Culiacan, Sinaloa, Mexico.

RHODES, WILLIAM B., Care Cia. Minera Jesus Maria y Anexas,

San José de Gracia, Sinaloa, Mexico.

- RICH, FRANK A., Cons. Engr., Rich & Roche, Phoenix Chambers,
Queen St., Auckland, New Zealand.
- *Richard, Francis C., Met.....5 Owen St., Carlton, Victoria, Australia. '09.
- RICKARD, BRENT N.....1546 William St., Denver, Colo.
- ROGERS, ALLEN H.....201 Devonshire St., Boston, Mass.
- ROWAND, LEWIS G.....New Jersey Zinc Co., 55 Wall St., New York, N. Y.
- RUETSCH, RUDOLF.....67 Fort Greene Pl., Brooklyn, N. Y.
- SAYRE, MORTIMER F., Instructor, Columbia Univ. Surv. School, Morris, Conn.
- SCHADER, HERBERT G.....Kingman, Ariz.
- SHALER, MILLARD K., Chief Engr., Soc. Forestière et Minière du Congo,
Kinshasa, Congo Belge, West Africa.
- SHAW, HOWARD I.....Lakeside, Cal.
- *Smith, Charles H., Min. Engr., Asst. to Prest., Davis Coal & Coke Co.,
Continental Bldg., Baltimore, Md. '10.
- STANTON, ROBERT B.....32 Nassau St., New York, N. Y.
- STAPLES, CHEVALIER B.....Wycliffe, B. C., Canada.
- **Taber, Stephen, Geol., Care Virginia Geological Survey....University, Va. '10.
- *Tsukakoshi, Umenoshin, Chem., Copper Queen Cons. Mining Co.,
Douglas, Ariz. '10.
- *Tyssowski, John, Min. Engr., Editorial Staff, *Engineering and Mining Journal*,
505 Pearl St., New York, N. Y. '10.
- VANDERLIP, WASHINGTON B., Care Barker & Conger,
31 Nassau St., New York, N. Y.
- WATTERS, DANIEL M.....Seattle Engr. Co., Central Bldg., Seattle, Wash.
- WELSH, NORVAL J. E.....R. F. D. No. 8, San Antonio, Texas.
- WHITE, RUSH J.....Wallace, Idaho.
- WILTSEE, ERNEST A.....P. O. Box 247, Bakersfield, Cal.
- WOAKES, ERNEST R.....6 Queen St. Place, London, E. C., England.
- WOLF, HARRY J., Genl. Mgr., Japan-Flora Mines & Tunnel Co., Telluride, Colo.
- *Woodworth, Robert B., Civ. Engr.....427 Carnegie Bldg., Pittsburg, Pa. '10.
- WORTH, JOHN G.....27 William St., New York, N. Y.
- *Yates, Arthur, Min. & Met. Engr., Genl. Mgr., Ketahoen Gold Mining Co., Ltd.,
Lebong Soelit, Sumatra, Dutch East Indies. '10.
- YATES, EDWIN F.....Bureau of Public Works, Manila, P. I.

ADDRESSES OF MEMBERS AND ASSOCIATES WANTED.

Name.	Last Address on Records, from which Mail has been Returned
Alexander, George E.,	Sparta, Ore.
Badger, Harry S.,	Goldboro, N. S., Canada.
Bailey, Marc,	Fort Dearborn Bldg., Chicago, Ill.
Bartoccini, Astolfo,	214 E. 90th St., New York, N. Y.
Bassett, Thomas B.,	Cumpas, Sonora, Mexico.
Batchelder, Joseph F.,	54 1st St., Portland, Ore.
Beck, Edwin L.,	Jardine, Mont.
Bellam, Henry L.,	Reno, Nev.
Blow, John J.,	172 Rodney St., Brooklyn, N. Y.
Bouchelle, James F.,	22 Duncan Ave., Jersey City, N. J.
Brown, Frank H.,	Coppermount, Alaska.
Calero, Jose,	Pachuca, Hgo., Mexico.
Campa, Jose,	Mexico City, Mexico.
Claudet, H. Hayman,	Rossland, B. C., Canada.

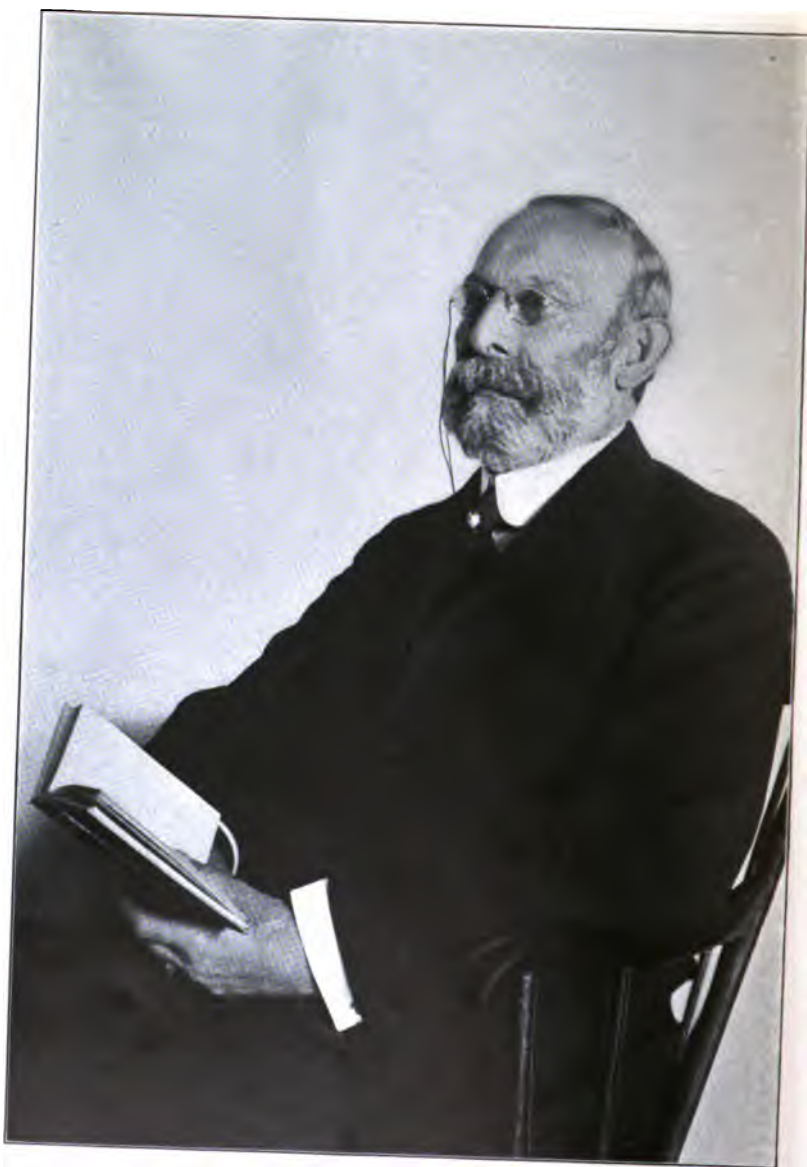
Clemens, Fred Le Roy,	Reno, Nev.
Cragoe, A. Spencer,	Vencedora, Mexico.
Daniel, Mark,	United Elkhorn Mines, Baker City, Ore.
Denny, George A.,	Salisbury House, London, E. C., England.
Dickson, George H.,	Lethbridge, Alberta, Canada.
Dougherty, Clarence E.,	41 Wall St., New York, N. Y.
Downs, M. E.,	25 Broad St., New York, N. Y.
Ekberg, Benjamin P.,	Johannesburg, Transvaal, So. Africa.
Field, Wilfrid B.,	Mexico City, Mexico.
Fitch, Frank,	Black Mt. Min. Co., Magdalena, Mexico.
Foster, Lewis E.,	Utah Copper Co., Garfield, Utah.
Gaines, Ambrose P.,	Dayton Coal & Iron Co., Dayton, Tenn.
Geppert, Richard M.,	Ray, Ariz.
Greenley, Louis A.,	Prairie City, Ore.
Hunt, Thatcher R.,	Iron Mt., via Keswick, Cal.
Jewett, Eliot C.,	2918 Morgan St., St. Louis, Mo.
Kow, Tong Sing,	Shanghai, China.
Leslie, Roscoe R.,	Goldfield, Nev.
McCan, E. K.,	Braden Copper Co., Graneros, Chile, S. A.
McGregor, J. Murray,	3 Minanciho, Ushigome, Tokyo, Japan.
Mildon, Reginald B.,	Nacozari, Son., Mexico.
Moulton, Herbert G.,	Cobalt, Ont., Canada.
Muir, Thomas K.,	Portland, Ore.
Piper, John W. H.,	Buenos Ayres, Argentine Rep., S. A.
Potter, J. A.,	41 W. 124th St., New York, N. Y.
Reece, Frederick B.,	Mogollon, N. M.
Ripley, G. Clinton,	Craft, Cal.
Robertson, Philip W. K.,	Real del Monte, Hidalgo, Mexico.
Sandifer, Harmer C.,	El Oro, Mexico.
Sanford, Chard O.,	Goldroad, Ariz.
Scott, Winfield G.,	Long Beach, Cal.
Skelding, Joseph F.,	Embreeville, Tenn.
Thomas, Richard A.,	43 Wall St., New York, N. Y.
Weddle, Joseph H.,	San Juancito, Honduras, C. A.
Wilson, Odell,	Shingle, Cal.
Wolfe, Burton L.,	Ely, Nev.
Young, William,	Kenora, Ont., Canada.

NECROLOGY.

The deaths of the following members have been reported to the Secretary's office during the month of May, 1910:

Date of Election.	Name.	Date of Decease.
1871.	*William P. Blake,	May 22, 1910.
1891.	*Charles H. Ferry,	May 2, 1910.

* Member.



Chas. B. Dudley

Biographical Notice of Charles B. Dudley, Ph.D.

BY R. W. RAYMOND, NEW YORK, N. Y.

(Pittsburg Meeting, March, 1910.)

In the long list of our illustrious and lamented dead, there are names which recall personality as well as career and achievement; social as well as scientific merit; devotion to the Institute itself as well as to some one of the professions which it represents. These men we remember because they did not forget us; besides our pride in their wider work and fame, we are proud of what they did with and through us; especially do we rejoice if our early recognition of them opened the way to a recognition by the world; and in their departure we claim to sorrow, not merely as members of an appreciative public, but also as bereaved personal friends. In common with thousands, we regret our loss, but we do not regret only—we mourn and miss. To this group of those whose death has brought to us the double sense of public and private grief belonged our strong, bright, dear brother, in whose memory this inadequate tribute is offered.

Charles Benjamin Dudley was born July 14, 1842, at Oxford, Chenango county, N. Y. He came on both sides of New England blood, his father being from New Hampshire and his mother from Connecticut. Emigrating from the rocky hills of their native States, they settled upon the more fertile soil of what was then regarded as the West, and, with thousands of other pilgrim sons, imitating the pilgrim fathers, contributed to the foundation of new commonwealths. The Empire State owes much to this element of its population.

Dudley's early education was obtained, like that of the sons of the pioneers generally, by attending the village school and academy in the autumn and winter, while he worked upon the farm during the rest of the year. But his ambition looked forward to a college-course; and this was almost within his reach when a passion still stronger took possession of him. The out-

break of the War of the Rebellion appealed to his patriotic enthusiasm; and, in 1862, at the age of 20, he enlisted as a private in the 114th New York Volunteers. During the following three years he took part in seven battles, gaining his experience of the routine as well as the adventure of war in all parts of the country, but mainly in the Southwest, and under circumstances of discomfort and discouragement most trying to the patience and courage of our soldiers. He was at the siege of Port Hudson in 1863, and went through the disastrous Red River campaign of the spring of 1864. But, after that campaign, he was transferred to Virginia, where, on Sept. 19, 1864, at the battle of Opequon Creek, fought near Winchester, and not long before the more famous battle to which Winchester gave its name, he received a severe bullet-wound, which rendered him incapable of further active duty. It left him, indeed, partially crippled for life, with a bullet in his leg as a perpetual reminder of the source of his disability.

But Dudley was one of those citizen soldiers who went into the War, not because they loved war, or expected to make it a life-vocation. They undertook military service as a patriotic task, yet even when, in the performance of it, they became veteran soldiers, they did not become professional soldiers. Their hearts were in their homes; and their plans for the victories of peace were only temporarily postponed, not superseded, by the experiences of the camp. This is the explanation of the phenomenon, so often named with wonder, of the swift re-absorption of the Grand Army, at the close of the War, into the ranks of the people from which it had sprung. The soldiers went home, where they had always longed to be, and resumed the work which they had laid aside at the call of a higher duty. At least, this is true of Dudley, and, as I believe, of many like him. As an illustration of his attitude towards the work of a private soldier, which he performed with as much fidelity and gallantry as if it had been his life-work, I may recall that, in 1863-4, when the Union forces in Louisiana went into winter-quarters, he had his Latin grammar and reader sent to him from home, and spent in the study of Latin the spare hours of that period. Unfortunately, through a capture of the stored camp-baggage, after active operations had been renewed, these books became the property of the enemy;

but the enemy had little opportunity, after that, to make use of the classics, and Dudley, meanwhile, had put the contents of the books where they could not be captured, unless he were captured with them.

Upon his discharge in 1865, he returned at once to his rural home, and took up his life again, just where he had laid it aside. I had almost written, "laid it *down*"—and if I had done so, I could have defied the critic and the proof-reader, for he had as truly laid it down as if the sacrifice had been accepted and ratified by death. That the life thus freely offered was returned to him, did not impair the completeness of the sacrifice. His escape from the death he had dared was only a Voice which said, "I have further use for thee!" So, at least, I understand it; and so, at least, did he! And I must add here, as a part of my picture of the man, that he never "traveled" on his military record. He did not run for office on the strength of his army service, or urge it as a claim to civil distinction or preference. I think he regarded it as an episode, such as every good citizen should meet like a man—without bragging about it afterwards. I think he would as soon have paraded his honesty as his patriotism. Such things, in his view, "go without saying."

So the crippled veteran of 23 went back to the Oxford Academy to prepare for college, with nothing to show in that line for the three years he had lost except what he had managed, in camp, to get out of his Latin grammar and reader, and, possibly, also a certain amount of fidelity, patience, and indomitable perseverance and courage, which had been both revealed and trained in the service of his country. And in 1867, as a man of 25 years, he modestly entered the Freshman class at Yale, along with a host of youngsters, who had not wasted any time in soldiering. Moreover, he did not cut short his college course on the ground that so much time had been lost, but went through the whole of it, shirking nothing, just as if it had been simply another campaign, and finally, in 1871, took his degree as A.B. with his class.

I make no apology for dwelling at such length upon these mere preliminaries of Dr. Dudley's career. For, to my mind, the secret of the man's character, and of his consequent success, is indicated in these very things.

I have known wise parents many, who, being able to give their sons all the advantages of a thorough education, have put them through a complete collegiate course as a preliminary to a professional course, before launching them into active and independent life. Happy the father, whose son is willing to wait so long, and is not spoiled meanwhile by scholastic life for the life of work among men which is to follow! And happy the son, who understands the value of such a preparation, and whose father is able and willing to pay the bills! (According to my observation, the wise fathers are more numerous than the wise sons!)

But I do not recall a single instance, except that of Charles B. Dudley, in which a youth has framed for himself a plan of thorough education of that sort, has "lost" three precious years in obedience to a higher duty, and has then returned to the prosecution of his original plan, without counting at all the time thus "lost."

To complete the picture of this extraordinary case, I should say that, when Mr. Dudley was graduated at Yale in 1871, he had no money to pay for the further schooling which he desired, and was, besides, in debt for money which he had been obliged to borrow to enable him to finish his college-course, although the amount thus owed was relatively small, because he had paid a large part of his expenses by outside work of all kinds. Under these circumstances, he did not look about for some patron who would lend more money in aid of a promising student, but set himself at once to earn what was required, both to repay his debt, and to furnish him for future progress. In other words, having already given three years to his country, he now gave another year to his personal honor. This year he spent in work as night-editor of the New Haven *Palladium* and the *Yale Courant*, successively, and in other employments, which enabled him to achieve at last his cherished ambition, and enter the Sheffield Scientific School of Yale University, from which he was graduated in 1874 as Ph.D. He had devoted himself, during his two years' course, to study and practice in chemistry; and his graduating thesis, afterwards published in full abstract in the *Proceedings of the American Association for the Advancement of Science*, was on "Lithium, and a Glass Made with Lithium."

At this point, I would pause again to call attention to the exceptional character of this example. Here is a man who has become 32 years old before entering upon his professional work. The delay has been due to intervals of three years and one year, sacrificed by the man himself, at the call of what he deemed higher duty—the first to patriotism, the second to personal honor. But the original plan of the youth has been carried out, irrespective of these interruptions, without one iota of abridgement or change; and the man stands at 32 where he might have stood at 28, or even (if he had decided to skip his classical college-course, and plunge at once into his technical course) at 24.

Yet, does he really stand only where he would have stood four or eight years earlier, if no time had been “lost”? Is it nothing that a man, having been a soldier, knows how to be a comrade—to meet and understand and win to hearty co-operation other men? Is it nothing that, having gained through a classical education the ability to comprehend the lessons of history and the inherited associations which actuate, even unconsciously, the men of to-day, he is able to communicate convincingly to others what he knows himself? Is it nothing that he has shown himself to be a lover of his vocation, yet capable of sacrificing even his vocation to duty and honor? Finally, is his certified professional ability less likely to win professional employment and success, when backed by that other certificate, furnished by a wide experience with men and their enterprises? These and other like questions are answered by the subsequent career of Dr. Dudley, which illustrates the deep utterance of Browning: “Get thy tools ready; God will find thee work.”

The first year after his graduation from the Sheffield School he spent as Assistant to Dr. George F. Barker, Professor of Physics at the University of Pennsylvania; and his success in this position led to a call, which he accepted in September, 1875, to the position of teacher of science in the Riverside Military Academy, of Poughkeepsie, N. Y. But before entering upon the duties of this position, he resigned it to accept the place thenceforth the center of his activity and influence—namely, that of Chief Chemist of the Pennsylvania Railroad Co., which he assumed Nov. 10, 1875, and held until his death.

During his service as Professor Barker's assistant, he had given, so far as I am aware, no evidence of his general interest in the progress of applied science, except the publication in the *Franklin Institute Journal* of some translations of German technical papers; and what directed to him the attention of the officials of the Pennsylvania Railroad Co., I do not know. Very likely some one of the keen, wise managers of that company had met and measured the man himself. At all events, this is certain: they made a fortunate choice when they chose him.

At that time the employment of chemists, or other professional experts, by great corporations was, though not altogether unknown as a temporary expedient, scarcely recognized as a part of the regular organization of such enterprises. Whatever partial precedents may be adduced, it cannot fairly be denied that the appointment of Dr. Dudley by the Pennsylvania Railroad Co., coupled, as it was, with the provision of ample laboratory-facilities for him, and, above all, with a sincere recognition of the value of his advice and an uncompromising execution of his recommendations in the execution of business contracts, was an epoch-making event. And the choice of the right man for the place was fortunate, not only for the Company and for him, but also for many other companies, whose course was influenced by the result of this experiment, and for many other experts who were afterwards, in consequence of this successful example, similarly employed as the permanent scientific advisers of great corporations.

When the Pennsylvania Railroad Co. created the experimental and advisory department at the head of which Dr. Dudley was placed, it was purchasing enormous quantities of materials, ranging from iron and steel to oil, paint and soap, but it had no scientific and systematic means of testing these materials before using them, or of framing specifications in advance for the guidance of manufacturers. Indeed, the maintenance of a separate department for criticism, investigation, and suggestion, in connection with any large enterprise, was practically new. The leading railroad companies had set the example by their thorough auditing departments; and the establishment of such a department, of even wider scope, by Carnegie, Phipps & Co., had proved that a great manufactur-

ing concern could profitably employ, in merely critical and advisory work, an expensive crop of "non-productive" skilled laborers, keeping accounts not merely with individuals but with furnaces, processes, and raw materials. But the Pennsylvania Railroad Co. was itself a manufacturer, as well as a consumer; and Theodore N. Ely, the Superintendent of its motive power, conceived the plan of an auxiliary department of tests and experiments, including a chemical laboratory. Dr. Dudley's work as the Chief Chemist and head of that department occupied the remaining thirty-five years of his life, and made him useful and famous throughout the world. He discovered and perfected tests, or prepared specifications, for all important materials used by the company, such as coal, water, lubricating-oil, paint, steel, iron, etc. It is reported that there are now between forty and fifty sets of specifications, physical or chemical or both, for the chemical provisions of which Dr. Dudley was directly responsible, while his advice largely influenced the physical provisions. The chemical laboratory employs twenty-seven persons, of whom twenty-three are regularly educated chemists, one being also a trained bacteriologist, who is occupied in the examination of water-supplies, disinfectants and their use, and tests for medical diagnosis required in the administration of the Company's Relief Fund. The number of tests and chemical determinations made in connection with materials offered for acceptance amounts to about 60,000 per annum. The story of the ventilation of passenger-cars, investigated in this laboratory, and resulting in the development of a satisfactory system, furnishes one of the many instances in which the benefits of this institution have extended far beyond the business of the corporation which it primarily serves. Another instance is the exhaustive study of explosives, which bore fruit in the formulation of rules governing the transportation of these and other hazardous materials.

In the course of his experiments and investigations, Dr. Dudley made many inventions and discoveries, for the great majority of which he never took out patents, "having," as he used to say, "no time for that." One of them, the design of the wick and burner for a railroad-lantern, is now in use everywhere. In another class of his discoveries—namely, the perfection of rapid and accurate commercial tests and analyses—

belongs the origination of a method for the detection of the presence of cotton-seed oil as an injurious adulterant of liquid lubricants.

In the conduct of his great work, Dr. Dudley pursued the policy of a frank contribution and exchange of the knowledge obtained. I do not mean to say that he kept nothing secret, in the business interests of his employers, or in fairness to others. But, instead of adopting the easy course of saying nothing, if he could not tell everything, he obeyed a wise, as well as generous, impulse to make known as much as he could. The result was not only most creditable to him, but most helpful to his special work. No better example can be given than that of his activity as a member of this Institute, which he joined in 1878, perceiving the possibilities of world-wide professional co-operation through such a medium.

He lost no time in proving his desire for such fraternal exchange; for he was not one of those who hoped to get without giving—like a man who wrote me, not long ago, that, after having been a member for a number of years (during which he had made no contributions to the *Transactions*), and having found nothing in our publications bearing upon his specialty, he thought he might as well resign! To say nothing of the selfishness of such a view, it is clearly short-sighted. He who would hear something ought to say something. Mere air may rush to fill a vacuum; but professional co-operation does not. Let Dr. Dudley's history point this moral!

In 1878, as a new member of the Institute, without waiting to get light by simply "keeping dark," he contributed to the *Transactions* his paper on The Chemical Composition and Physical Properties of Steel Rails,¹ embodying the results of numerous experiments and much thought. That contribution "fired a shot heard round the world." The pages of our *Transactions* bear abundant witness to the extent of the interest which it aroused and the value of the discussion which it elicited. The theories and formulas which it tentatively proposed have been modified or superseded since, partly by his own subsequent investigations; but it placed its author in the front rank of investigators, and gave to the Institute a leader-

¹ *Trans.*, vii., 172 (1878-79).

ship in that field not yet wholly lost. Whoever studies the relation of the physical and chemical factors in steel, and the history of its scientific elucidation, will find himself repeatedly referred to Dudley's great paper and its discussion; and no better summary of the latest results of the long debate can be found than his address on Some Features of the Present Steel Rail Question, delivered before the American Society for Testing Materials in 1908.

The following list of Dr. Dudley's contributions to the *Transactions* indicates their range and value. His ability and zeal were promptly recognized by his fellow-members, who elected him in 1880 a Vice-President of the Institute.

CONTRIBUTIONS.

Papers.

- The Chemical Composition and Physical Properties of Steel Rails. Vol. VII., p. 172.
 Does the Wearing Power of Steel Rails Increase with the Hardness of the Steel? Vol. VII., p. 202.
 Wearing Capacity of Steel Rails in Relation to their Chemical Composition and Physical Properties. Vol. IX., p. 321.
 (C. B. Dudley and F. N. Pease) Notes on the Constitution of Cast-Iron. Vol. XIV., p. 795.
 The Wear of Metal as Influenced by Its Chemical and Physical Properties. Vol. XIX., p. 892.
 The Making of Specifications for Structural Materials. Vol. XXI., p. 379.
 Standard Specifications for Cast-Iron Car-Wheels. Vol. XXXV., p. 189.

Discussions and Remarks.

- Of his Rail papers in Vol. VII. Vol. VII., pp. 393, 413.
 Of his Rail paper in Vol. IX. Vol. IX., p. 588.
 Of Witherow's paper on The Clapp-Griffiths Converter. Vol. XIV., p. 938.
 Of Langley's paper, International Standards for the Analysis of Iron and Steel. Vol. XIX., p. 635.
 On Magnetic Concentration of Iron-Ore. Vol. XX., p. 580.
 Of Hunt's paper, Tests and Requirements of Structural Wrought-Iron and Steel. Vol. XX., p. 703.
 Of Campbell's paper, The Influence of Carbon, Phosphorus, Manganese, and Sulphur on the Tensile Strength of Open-Hearth Steel. Vol. XXXV., p. 1046.
 Of Gayley's and Johnson's papers on Blast-Furnace Practice. Vol. XXXVI., p. 792.
 Of Roe's paper on Manufacture and Characteristics of Wrought-Iron. Vol. XXXVI., p. 811.

The foregoing list represents but a small part of his fruitful activity in technical literature. Another part is comprised in the two series of articles (more than fifty in all) published at

intervals during about fourteen years in *The American Engineer and Railroad Journal*, and intended to explain and recommend to manufacturers the specifications of the Pennsylvania Railroad Co., by stating the reason of such requirements, and describing the methods of the chemical tests involved. And to these must be added his numerous papers and addresses before technical societies, etc., of which I have been able to collect the following incomplete but suggestive list:

- Fuel Oil.* Lecture delivered before the Franklin Institute, Jan. 6, 1888.
- International Standards for the Analysis of Iron and Steel.* Reports of the Subcommittee on Methods, Charles B. Dudley, Chairman. (*Proceedings of the American Society of Civil Engineers*, 1889 and 1890.)
- Lecture on Paints and Painting Materials.* Delivered under the auspices of the Carriage Builders' National Association, Mar. 16, 1892.
- Address to the Members of the Chemical Section of the Engineers' Society at Pittsburg,* Sept. 27, 1892.
- Standard Methods for the Analysis of Iron and Steel.* Read before the Engineers' Society of Western Pennsylvania, Oct. 24, 1893.
- An Attempt to Find the Amount of Phosphorus in Three Samples of Steel, and Some Points in the Determination of Phosphorus in Steel by the Volumetric Method.* By Charles B. Dudley and F. N. Pease. *Journal of the American Chemical Society*, Vol. XVI., No. 4, April, 1894.
- The Theory and Practical Use of Inert Pigments.* "Drugs, Oils, and Paints," October and November, 1896.
- Some Present Possibilities in the Analysis of Iron and Steel.* Read before the American Chemical Society, Dec. 29, 1896.
- The Ventilation of Passenger Cars on Railroads.* *Journal of the Franklin Institute*, July, 1897.
- The Dignity of Analytical Work.* Presidential Address. Read before the American Chemical Society, Dec. 29, 1897.
- Report of the Committee on Coal Analysis.* By William A. Noyes, W. F. Hillebrand, and C. B. Dudley. *Journal of the American Chemical Society*, Vol. XXI., No. 12, December, 1899.
- Disinfection of Passenger Cars.* By C. B. Dudley, Chemist, and M. E. McDonnell, Bacteriologist, of the Pennsylvania Railroad Co. *American Engineer and Railroad Journal*, June, 1902.
- The Making of Specifications for Materials.* President's Address. *Proceedings of the American Society for Testing Materials*, Vol. III., 1903.
- A System of Passenger-Car Ventilation.* Read April 8, 1904.
- Oils and Pigments.* Lecture before the Sixteenth Annual Convention of the Master House-Painters' and Decorators' Association of Pennsylvania, Jan. 14, 1904.
- The Passenger-Car Ventilation System of the Pennsylvania Railroad Company*, 1904.
- The Influence of Specifications on Commercial Products.* President's Address, American Society for Testing Materials, June, 1904. *Proceedings*, Vol. IV., 1904.
- The Testing Engineer.* President's Address, American Society for Testing Materials. *Proceedings*, Vol. V., 1905.
- The Dissemination of Tuberculosis as Affected by Railway Travel.* Read at the annual meeting of the American Public Health Association, September, 1905.

The Enforcement of Specifications. President's Address, American Society for Testing Materials. *Proceedings*, Vol. VII., 1907.

Some Features of the Present Steel Rail Question. President's Address, American Society for Testing Materials. *Proceedings*, Vol. VIII., 1908.

Engineering Responsibility. President's Address, American Society for Testing Materials. *Proceedings*, Vol. IX., 1909.

This wonderful aggregate constituted one of the most potent factors in that harmonious union of practitioners with critics and investigators which has produced the rapid progress of the arts as well as the sciences among us. Each of these classes has reacted as a stimulus upon the other; and Dudley represented both.

He was a member of the American Societies of Civil and Mechanical Engineers; the American Institute of Electrical Engineers; the American Electro-Chemical Society; the Franklin Institute; the American Philosophical Society; the Academy of Science; the American Railway, Historical, Forestry, and Public Health Associations; the Iron and Steel Institute of Great Britain; the *Verein deutscher Eisenhüttenleute*; and numerous English, German, and French chemical societies. He was twice President of the American Chemical Society, and four times of the American Society for Testing Materials; President of the Bureau of the American Railway Association for the Safe Transportation of Hazardous Materials; and Chairman of the Committee on Explosives of that association. At the time of his death, he was President of the International Association for Testing Materials. He was one of the founders of the Juniata Club in Altoona, and a member of the Cosmos (Washington, D. C.), Union League (Philadelphia), and Engineers' (New York) clubs.

The town of Altoona, which his work helped to make famous throughout the world, owes him a great debt of gratitude. He was the President of its first Board of Health, and placed at its service his scientific knowledge and business sense in the establishment of good sanitary conditions. The Pennsylvania Company, which owns so large a part of the town and employs so large a part of its population, had given him its complete confidence, and was accustomed to "do what Dudley said;" and his unselfish labors won for him likewise the confidence of his townsmen; so that he had, in many respects, the power of

a dictator. Yet he was but "the servant of all," and only in that best sense a ruler. One of the institutions which bears the marks of his helpful guidance is the Altoona Mechanics' Library, of which he was an officer, and for which, aided by the Pennsylvania Railroad Co., he acquired many well-selected technical books and files of scientific periodicals. The library now contains more than 45,000 volumes, comprising, besides adequate provision in general literature, history, travel, and fiction, a collection of standard books of reference in science and technology which many a college might envy.

But it was not as a kindly patron from some larger sphere, bestowing benefits incidentally, as it were, upon a community in which he had only a benevolent interest, that Dr. Dudley served the town of Altoona. He regarded it as his home; he invested in it his savings; and on its eastern edge he had a farm, to which, rather than to fashionable watering-places or foreign lands, he retired for rest and recreation. He had made four journeys to Europe, having been sent in 1886 to study, in Russia especially, the use of oil as a fuel in railway-locomotives, and again in 1900 as a delegate to the International Railway Congress at Paris. In 1906, he spent a happy three months' vacation in Italy, with his wife; and in 1909 he made another transatlantic trip. But round the world, as here among us, he was known and hailed as "Dudley of Altoona." The journey of 1909 was made for the purpose of attending as a delegate from the United States the Copenhagen meeting of the International Society for Testing Materials. It was at this meeting that he was enthusiastically elected President of the Society by the 900 delegates present from all parts of the world. This honor touched him deeply, and his satisfaction was increased by the selection of the United States, upon his invitation, as the country in which the next international meeting should be held. In extending this invitation, Dr. Dudley promised that the sessions should be carried on in English, French, and German. He felt that the proper execution of this promise involved the use of these languages by the presiding officer, and he was conscious of his own inability, through lack of practice, to speak freely in French or German, although he could read both languages with ease. It was characteristic of him, that immediately after the meeting at Copenhagen, he began

to take lessons in talking French and German, and devoted to that purpose every available hour of his time thereafter. It is not easy for a man approaching seventy years to acquire facility in a new tongue; but I firmly believe that Dr. Dudley would have conquered this difficulty before 1912.

The story of his final illness and death is brief. Up to the middle of December, 1909, he was, as we were all accustomed to see him, full of vitality and unimpaired in his enthusiasm and power for work. But on Friday, Dec. 17, he returned to Altoona from a two days' visit to Washington, D. C., where he had contracted a severe cold. The next day pneumonia was developed; on Sunday his condition became alarming; and on Tuesday evening he died. We are told on high authority that pneumonia is one of the very few maladies in dealing with which modern medical science has made little or no progress. It seems a cruel mockery of our human knowledge that this one unconquered foe should so easily overcome a great scientific leader. Yet, if we contemplate the character of the man, and the work he had already accomplished for his kind, we may rather lament our own continued careers than that which was so suddenly cut off. If, using the method of engineers, we should estimate the value of a life by multiplying its years into its achievements, who of us might not envy this record? And if, in similar fashion, we take account of its momentum, as it disappears from our mortal view, who of us will dare to say it has ceased to advance, because we have ceased to see it? Is anything ended, except our power of seeing?

I cannot do better, in summarizing both the qualities of Charles B. Dudley and the impressions which they produced upon others, than to quote the following paragraphs from the minute of the Executive Committee of the American Society for Testing Materials, prepared by Prof. Henry M. Howe, past-President of that Society, of which Dr. Dudley himself was President at the time of his death, and Dudley's successor as the President of the corresponding International Society:

"Let us record at once our deep grief and our deeper gratitude, our grief indeed at the loss of a great leader and dear friend, but above all, our gratitude that we have had the privilege of being led.

"Such measure of usefulness as our Society has had, it owes in very large part to that leadership. Here was a most rare combination of qualities, the sterling,

the intellectual, the human, the judicial, each on a high level, all combining to form a character, a personality, whose like we shall not look upon again.

"With a clear head to see the world's needs, to part the essential from the accidental and the merely concomitant, went the skillful and persuasive tongue to make clear to the rest of us what he had first made so clear to himself. With these went the perfect fearlessness, apparently even the unconsciousness of either danger or fear, which made him lead on where others would have flinched. With these again went his calm, clear, good judgment, which seemed to tell him spontaneously which among the good things that needed doing were the most worthy of being done, and what were the best and surest ways of doing them.

"With all these admirable qualities went that which was necessary to the accomplishment of his high purposes, his kindness of heart, his sympathy and his tact, which made us all his allies in what he undertook. Had he a proposal? Our affection and veneration for him made us almost its advocates before it was unfolded. Its intrinsic wisdom, and the clearness with which he expressed it, found an audience ready, almost anxious, and certainly expecting to be convinced."

Though keenly aware of the inadequacy of my notice of this great leader, bright example, and dear friend, I cannot believe that I have wholly failed to set forth beyond misunderstanding the features which seem to me most important and inspiring in his career—namely:

1. He was among the first to furnish in this country a conclusive demonstration of the value of scientific aid in business enterprises.

2. The demonstration which he thus furnished proceeded from his own versatile and sympathetic character, and consisted in the tactful combination of practical application with theoretical research.

3. The extraordinary effect of his labors in this field was enhanced by the fraternal spirit in which he shared their results with other workers in the same field.

4. And supremely important, in his work, was his personality; the unfailing sweetness, cordiality, and victorious joy of his temperament. He loved the world; he loved his fellow-men; and we loved, trusted, and followed him!

I have reserved to the last an observation for which I could find no appropriate place in the above text, yet which seems to me essential to a full view of Dr. Dudley's life.

We who were personally intimate with Dr. Dudley had become accustomed to regard him as one of those "bachelors of science" who, though they had long ago become "Masters"

and "Doctors," still held to the celibacy connected, in old times, with their first degree. And when we learned of his marriage, Apr. 17, 1906, to Miss Mary V. Crawford, of Bryn Mawr, Pa., we rejoiced that, even so late, he had found the home-life which he so well deserved, and for which he was so well qualified. Our hopes and congratulations were not disappointed. We saw how that experience renewed his youth; we read upon his face the one last word of charm; we recognized the flying signal of a heart, anchored at last in a happy home. And, even in this public place, we would offer, together with our praise of him, both our sympathy and our congratulations to her whose affection added flowers of crowning joy to the laurel-leaves of his fame!



Combustion in Cement-Burning.

BY BYRON E. ELDRED, NEW YORK, N. Y.

(Pittsburg Meeting, March, 1910.)

GENERALLY speaking, the practical study of combustion has been made mainly from the stand-point of the steam engineer. This narrow view-point has left open a large field for scientific research on the application of combustion in other arts, where the conditions of heat-utilization are widely different from those presented in the steam-generator. The great economic importance of the boiler and the ease of measuring its performance, together with the comparative uniformity of conditions in the steam-generator, is, probably, quite largely responsible for the practical neglect of the study of the use of fuels in other arts save only on the basis of their thermal value.

Yet these other arts show quite plainly that a thermal-value basis alone is not sufficient. For example, in burning lime, under ordinary conditions of firing, a cord of wood will do as much work as a ton of coal, though the latter affords more than twice the number of heat-units. Similar results are evidenced in burning brick, in the roasting of certain ores, in reheating billets, and in many other arts where heat is to be applied over extended areas to fragmental masses of more or less refractory materials. In these arts much is to be gained by a careful study of the application of the heating-agent in the form of the long flame, and in the production of the heat in contact with, or in direct proximity to, the object to be heated. Of necessity, in boiler-practice, combustion cannot be maintained in actual contact with, or in close proximity to, the object to be heated.

Speaking in a general way, heat is imparted from burning bodies to things to be heated in two ways: directly, by radiation, and indirectly, by transfer of the sensible heat of hot gases by convection or contact; by conduction from the hot gases. Both ways are utilized in boiler-practice—directly, by

the radiation from the flame and from furnace-walls, and indirectly, by the heating-effect of currents of hot-flame gases. But because the thing to be heated, the water or its metal container, is always at a temperature which will extinguish flame, the heat is always generated elsewhere and conveyed to the boiler; it cannot be produced at the point where it is wanted. Again, the very wide and essential difference between the heating of water and the work performed by heat in other arts lies in the property of the liquid to distribute the heat evenly throughout its mass.

Different conditions prevail in other arts; but these conditions have not been well studied, and our practice is crude. As regards radiation, the old axiom that the power of a body to intercept heat is inversely proportional to the square of its distance from the source of the heat, is still worth consideration. The application of pre-generated heat to extended areas of fragmental, more or less refractory materials, in the same way as in the boiler-furnace, is wasteful and unsatisfactory. This is the reason for the preference of long-flame fuels for certain work, and the reason why gas-producers are run with shallow fuel-beds for soaking-pits and billet-reheating furnaces; the reason why lean gas is wastefully produced at a much greater expense than the richer gas from the more economically operated producers that supply the open-hearth furnaces. The lean gas gives a different type of flame; a slower, longer flame suitable for the comparatively low, slow heating of solid masses over extended areas.

This cited case of wasteful heat-generation to secure special application is a fair support for my statement that the study of the phenomena of applied combustion has been neglected. The fact has never been pointed out that the reason for this wasteful low-fire producer-operation is to secure later the flame-results of a lean gas carrying a large percentage of the neutral diluent gases, nitrogen and carbon dioxide, though, as respects the latter, it is perhaps hardly to be regarded as a purely neutral diluent. The gas-producer operator knows only this indirect way of securing a desirable end, while to any man of ordinary scientific knowledge, the mere suggestion of the end to be attained should suggest the better way of an economical manufacture of the producer-gas and the later use of waste

gases in admixture with air to produce the desired type of flame: a way which is susceptible of regulation and control.

In my studies of long-flame combustion, I have noted remarkably wide differences, and great advantages, in the application of the heating-agent to generate heat in contact with the work, as contrasted with the prior methods of applying pre-generated heat. The practical workings of this idea were investigated by a committee of the Franklin Institute about five years ago and reported on favorably; therefore, I will not go into further detail, and only offer the foregoing as a preface to the statement that I consider cement-burning as conducted in present-day accepted American practice a good demonstration of the crudeness of our application of the principles of combustion; and, to go a step further, of our lack of observation of the phenomena of combustion.

In the present practice of burning cement, the clinker is made by slowly passing a stream of finely-powdered cement materials through a rotary kiln of from 5 to 8 ft. internal diameter and from 60 to 150 ft. long. In the entrance of the kiln burns an aërially-supported flame-plume, generally axially directed, produced by powdered coal injected by air. In passing through the kiln, the materials, which are an artificial or a natural mixture of clay and calcium carbonate, are first dehydrated by the heat of the flame-gases. Then the carbonate is causticized by dissociation, or calcined, the carbon dioxide being driven off by heat, and finally the clay and lime unite to form the clinker.

Each of these operations, dehydration, calcining, and clinkering, has different thermal requirements, and yet in the ordinary practice all three are performed by one flame: a flame particularly adapted to the needs of the clinkering-operation and to that only. Clinkering requires a high temperature—a temperature sufficient to sinter the clay component and cause it to unite with the lime; but no great absorption of heat occurs; the action is exothermic. And as the calcines pass slowly under the blazing, heat-radiating coal-flame, they rapidly acquire the necessary temperature, and clinker. For the calcining, the waste heat of the flame-gases is considered all that is necessary; yet the marked economy of the slow-burning, voluminous flame for calcining is well known in other arts.

The net result is that the ordinary cement-kiln is a good clinkerer, a highly inefficient calciner (the calcines often come into the clinking-zone with a material percentage of their carbon dioxide remaining), and a very wasteful thermal device.

So far as combustion is concerned, the kiln is a horizontal flue, and, as in every other horizontal flue, whatever gas-stratification can occur will occur. Much does occur. The flame is purposely spaced away from the work in the clinking-zone, and the gases from it rise into the arch of the kiln and never get into effectual contact with the work in the calcining-zone. The heating in the calcining-zone is largely by radiation from the upper walls, and by direct conduction as the upper wall becomes the lower and moves under the onflowing stream of material. There is practically no direct heating by the flame-gases. These gases flow along the upper part of the kiln, and under them flows an entrained current of relatively colder air, partly brought in by the stack-suction and partly by the injector-action of the flame and coal-feeder.

Not only is the heating of the calcining mass inefficient, but the calcination is furthermore performed under the worst possible conditions. Calcination is a heat-absorbing reaction, and the evolved carbon dioxide is, therefore, relatively cold and dense, while it is naturally a gas of high specific gravity. It, therefore, tends to remain in the bottom of the kiln, flowing along as a separate stratum bathing the material, and very little admixed with the gases and air above. In other words, the carbonate is being calcined in an atmosphere of carbon dioxide; or, at least, an atmosphere which is abnormally rich in carbon dioxide. Now calcination is one of the reactions which, like evaporation, depends very much upon the ambient atmosphere. Other things being equal, and within certain ranges of temperature, the heat required to dissociate calcium carbonate is inversely as the percentage of carbon dioxide in the atmosphere. That is one of the reasons why the rotary kiln is so poor a calciner as compared with the vertical, separately-fired lime-kiln. In the latter, the pieces of dissociating limestone are always bathed in a constantly-changing atmosphere, which can never contain more than 21 volume per cent. of carbon dioxide (the theoretical maximum for products of

combustion), and which, as a matter of fact, never runs anywhere near as high as that amount.

In the vertical kiln, calcination and heat-utilization are very much better than in the rotary kiln, which is essentially a device adapted for the use of cheap fuel and expensive labor. And calcination, though not generally so recognized, is one of the most important functions of the cement-kiln. In the ordinary rotary kiln, the material comes into the vicinity of the clinkering-flame but partly calcined, and there is a sudden evolution of carbon dioxide at this point, disturbing the normal and orderly sequence of the operations and leading to the formation of clinker-rings and nodules.

As a labor-saving device the American coal-fired rotary cement-kiln was a great advance in the art over anything ever known before; but from the view-point of the heat engineer it is a grossly wasteful and inefficient apparatus. Though, theoretically, 25 lb. of coal should suffice for making a barrel of cement, the actual consumption is from 90 to 110 lb. Many attempts have been made to lessen this waste of fuel; but they have not embodied a scientific application of fundamental principles and, hence, have not been successful. Regenerators, recuperators, and the like cannot be employed with the present single kiln, for the reason, among others, that the dust evolved in calcining is carried forward by the violent rush of gases through the kiln and would soon choke up such heat-recovering devices, and also because of the necessity for unimpeded draft under the conditions of high localized heat-generation with the burning of fuel, taking into account the large air-excess requirements and the increase in volume of gases due to calcination-products.

Succinctly, in the ordinary kiln two wholly-unlike operations, clinkering and calcining, are performed by one flame; and the results, so far as calcination is concerned, are not good, while the heat-waste is enormous. It is obviously better to perform the two stages as two stages in two kilns, and use for each combustion-methods best adapted for that particular stage. In doing this, moreover, the possibility of using heat-recovering devices is afforded, since, as it so happens, the dusting is mostly obviated by slow-traveling flames in both steps, while the high-temperature gases from the clinkering-operation can

be used in regenerating the fuel for clinkering, and the lower-temperature gases from calcining can be used in regenerating for that operation, if desired, although this is less practicable. With the possibility of using regenerators comes the opportunity to use producer-gas, which, normally, gives rather too low a temperature for clinkering, in place of the more expensive powdered coal.

With this severing of the calcining from dependence upon the clinkering comes the practicability of a scientific utilization of combustion in the calcining-operation. The latter becomes a simple, lime-burning step, differing only in that the material, being finely powdered, cannot be handled in a vertical kiln and thus brought into actual contact with the flame and hot gases from ordinary firing-means. Something more than the ordinary type of boiler-furnace firing-means is necessary with fine material traveling down the rotary kiln. There must be a different type of flame: a flame filling the cylinder, and coming into actual contact with the material to be heated and there burning, in place of traveling along its top. It is, of course, possible to produce combustion in contact with material which, unlike water-cooled boiler-tubes, can be raised over a red heat; and in so doing, the law of the square of the distance is no longer so important. As a matter of fact, combustion is actually much more vigorous in contact with suitable refractory materials, such as lime, than elsewhere; a fact which will be apparent to any one who has seen the flames licking the furnace-walls. Recent scientific work has shown that this "wall action" much heightens the velocity of combustion and, concomitantly, the number of heat-units which can be evolved in a time-unit.

There are long-flame fuels; but few of them can be economically used in calcining cement materials, and fewer still will afford a flame capable of filling the barrel of the kiln. The flame of ordinarily good producer-gas is too short and scanty; and if it be burnt with regenerated air, as heat-economy dictates, it becomes still shorter. But the fat, long flame can be secured by the use of expedients which, looked at in one way, may be regarded as a development of the crude scheme of running the producer with an uneconomical "low fire." It is merely necessary to dilute the gas with a neutral

gas, or, which is simpler, to dilute the air used for combustion. Or a triple mixture of air, diluent gas, and combustible gas may be made. Let us consider this last as the simplest case. If a mixture of combustible gas and air in theoretical proportions be made, ignition, of course, results in an explosion; that is, in a practically instantaneous combustion. When one portion of the gases is brought above a red heat, combination takes place and heat enough to carry on the reaction is evolved simultaneously. Now let us progressively dilute the mixture with an inert gas, say nitrogen. As the dilution goes on, the mixture becomes less and less explosive, till finally a point is reached where the ignition will no longer propagate itself through the mass at ordinary temperature. A spark or a flame brings the mixture in its immediate vicinity to a red heat and induces a local combination; but the ignition does not propagate through the gas mass. It will not burn. Now let us raise the temperature of the gas mass. Obviously it will again burn, and in burning the gas will evolve heat. In other words, if we pass the mixture through a kiln containing red-hot or white-hot lime, it will then burn and will evolve heat. But, under the laws of "wall action," the burning will be most intense where the gas is in actual contact with the hot solids.

With the above in mind, it is evident that we have it in our power to dilate the flame; to cause it to be as long and as voluminous as we please. All we have to do is to dilute our gas with stack-gases, or to dilute the air for combustion. Stack-gases are better for this purpose than pure nitrogen, even were the latter available, for the reason that the contained carbon dioxide, for chemical reasons, has a combustion-retarding action much greater than that of nitrogen, so that our gas mass need not be so voluminous. If we dilute our air, we can burn oil or solid fuel, if we like, instead of producer-gas.

Presuming that we are burning producer-gas with air diluted with stack-gases, then, by a simple adjustment of the air-valve and of the stack-gas valve, we can make our flame lengthen and spread out till it fills the kiln. It does not burn at once and give gases rising into the arch; it burns all through the kiln, and it burns most rapidly at the point where it comes into contact with the powdered refractory material of the cement mix. In other words, we are developing a large part of our

heat where we want it, in place of developing it all somewhere else and then transferring it to where we want it. And in place of calcining the limestone in an atmosphere of nearly pure carbon dioxide, we are calcining it in an atmosphere of flame-gases, an atmosphere which cannot contain so great a proportion of that gas.

By the separation of the calcining and clinkering steps, we can employ a slow-traveling draft-current through the calcining-kiln, because it is not necessary to expel the products of combustion from a zone of intense heat to make room for fresh fuel. The calcination may be accomplished without regard to the clinkering-zone conditions, and regulation should secure a low temperature of chimney-gases, which, under present practice conditions, carry off approximately six times the heat of the discharged clinker; and practically half of the heat waste accounted for in the chimney-gases is carried by the excess air required to support the combustion of powdered fuel. Prof. Joseph W. Richards¹ reported a test of a rotary kiln showing his calculation of a heat-balance accounting for 72.1 per cent. of the total heat as lost in the chimney-gases.

The heat required for the combination of the clinker is variously estimated, but from 15 to 18 per cent. of the heat developed by the coal seems a fair proportion. Therefore, the clinkering-operation conducted in a separate kiln should require but little fuel and much less attention, as good clinker depends most largely on properly-calcined material.

What I propose for the calcination is the present rotary kiln, gas-fired with long-flame combustion. Such a kiln with such a gas-flame has produced more than 6 lb. of lime per pound of coal burned in a producer with low fuel-bed. "Good" gas-fuel reduced the output of the kiln materially. Next, I propose to take fritted calcines from the calcining-kilns to a special clinkering-kiln, which shall embody heat-regenerators and gas-firing. Open-hearth practice gives us an idea of this operation.

This plan has not yet been put into commercial operation. German scientists have thought well of it, and it was expected that a demonstration would take place near Berlin this spring, but from last reports little progress, except on paper, has thus

¹ *Journal of the American Chemical Society*, vol. xxvi., No. 1, pp. 81 to 88 (January, 1904).

far been made. We can, therefore, only consider theoretically this proposition of cement-burning in a two-kiln operation.

Let us assume the production of a theoretical cement of the following composition, on which heat-determinations will be calculated :

	Per Cent.
Lime, corresponding with 3 (Ca_2SiO_3) and 1 ($\text{Ca}_2\text{Al}_2\text{O}_3$),	68.55
Silica,	20.10
Alumina,	11.35

All of the other constituents found in commercial cement are accidental impurities.

To produce the cement, the ingredients will be used in the following proportions :

	Kg.
Limestone (CaCO_3),	122.32
Clay ($\text{Al}_2\text{O}_3 \cdot 2 \text{SiO}_2 \cdot 2 \text{H}_2\text{O}$),	28.75
Sand,	6.7
Total weight of mixture,	157.77

This amount of raw materials is required to produce 100 kg. of cement.

First, the mix must be heated to 900°C . to dehydrate the clay and decompose the limestone.

The heat-requirements for producing calcines are as follows :

For dehydrating the clay, there will be required 1,218 calories per kilogram of water dissociated from the clay. $2 \text{H}_2\text{O} = 4.01$ kilograms.

For dissociating CO_2 from limestone 1,026 calories per kilogram of CO_2 are required. It will be assumed that the specific heat of the mix is about 0.25.

$$157.77 - 4.01 = 153.76 \times 0.25 \times 900, \quad = 34,596 \text{ calories for heating.}$$

$$4.01 \times 1,218, \quad = 4,882 \text{ calories for dehydrating clay.}$$

$$122.32 \text{ kg. of } \text{CaCO}_3 = 53.76 \text{ kg. } \text{CO}_2 \times 1,026 = 55,157 \text{ calories for dissociating limestone.}$$

$$94,635 \text{ calories for producing calcines.}$$

For sintering, the heat-requirements are very much less ; in fact, the exothermic reactions produce one-third of the heat required for heating the calcines to the sintering-temperature. The heat of combination of lime with silica and alumina in cement does not seem to have been accurately determined,

but Le Chatelier found that in the combination of 3CaO , Al_2O_3 , 3SiO_2 , 150 calories were developed per unit of Al_2O_3 , 2SiO_2 , and as the silica and alumina exist in about that ratio in the cement, their sum multiplied by 150 calories will give the heat produced.

Clinkering.—For clinkering, estimating that the calcines are discharged directly from the primary kiln into the clinkering-kiln at 900°C ., and are therein heated to $1,300^\circ \text{C}$., a range of 400° rise in temperature, and assuming the specific heat of the calcines to be 0.30, $100 \times 0.3 \times 400 = 12,000$ calories are necessary. Therefore,

$$\begin{array}{rcl} 100 \times 0.3 \times 400 (1,300 - 900) & = & 12,000 \text{ calories absorbed by clinker.} \\ 31.45 (\text{SiO}_2 + \text{Al}_2\text{O}_3) \times 150, & = & 4,717 \text{ calories produced.} \\ \hline & & 7,283 \text{ calories absorbed from fuel.} \end{array}$$

This represents slightly less than 1 per cent. of fuel for clinkering.

The total heat-units in the clinker as discharged would be:

$$100 \times 0.3 \times 1,300 = 39,000 \text{ calories.}$$

The above calculation represents the heat-requirement, provided that the combustion-gases left the kilns cold, and that the carbon dioxide gas from the limestone left the kiln at the temperature of dissociation.

Calcing.—Practical working-tests with a gas-fired rotary kiln, 100 ft. long by 6 ft. in diameter, burning limestone crushed to 0.5-in. size, such limestone containing 98 per cent. of CaCO_3 , have shown that it is safe to assume an output of 6 parts of lime to 1 part of good gas-coal; therefore 68.55 kg. of lime would require 11.43 kg. of fuel, and as there are 68.55 kg. of lime in 100 kg. of cement, 11.43 kg. of coal would calcine all of the lime to produce 100 kg. of cement. There remains only the heat-requirement for bringing 31.45 kg. of $\text{SiO}_2 + \text{Al}_2\text{O}_3$ to the temperature at which the lime is formed. $\text{SiO}_2 + \text{Al}_2\text{O}_3 = 31.45 \text{ kg.} \times 0.25 \times 900 = 7,076$ calories, which would be equivalent to not more than 1 kg. of coal per 100 kg. of calcines; therefore, an estimate of work in the calcining-kiln would be:

11.43 kg. of coal for heat to produce 68.55 kg. of lime.

1. kg. of coal for heat to raise temperature of clay.

0.5 kg. of coal allowance for heat-losses in heating up clay.

12.93 kg. of coal per 100 kg. of calcines, or 1 of coal to 7 of calcines.

Assuming 180 tons to be clinkered per day in one clinkering-kiln, 180 tons = 180,000 kg. divided by 100 = 1,800 kg., or 1 per cent. There remain 39,000 calories in the discharged clinker, and assuming that one-third of this heat can be taken up by air-currents and supplied to the primary or calcining-kiln, 13,000 calories would be afforded, equivalent to 1.5 kg. of coal per 100 kg. of calcines, which, subtracted from 12.93 kg. of coal used in calcining, gives 11.43 kg., or 11.43 per cent., of fuel, or 1 of coal to 8.75 of calcines.

Assuming an efficiency of only 25 per cent. in the clinkering-kiln, or 4 kg. of fuel per 100 kg. of calcines, $1,800 \text{ kg.} \times 4 = 7,200 \text{ kg.}$ This would add 4 per cent. to the fuel-consumption, or 4 kg. per 100 to the 11.43 required for calcining = 15.43 kg. per 100, or 15.43 per cent. = 1 of coal to 6.48 of cement.

A regenerative system such as is shown by this plan is capable of utilizing for clinkering 84.2 per cent. of the total heat of the gas produced, and the producer should have an efficiency of 80 per cent., thus giving 67.36 per cent. efficiency for the combination of the producer and kiln, not allowing for loss by radiation. I believe it would be safe to assume 50 per cent. efficiency for the clinkering-kiln outfit, allowing 17.36 per cent. for loss by radiation. If this result should be realized, the process would yield 7.44 kg. of cement for each kilogram of coal consumed, based on practical working-tests with the gas-fired rotary kiln burning limestone crushed to pass a 0.5-in. ring.



The Giroux Shaft at Kimberly, Nev.

BY C. EVERARD ARNOLD, KIMBERLY, NEV.

(Pittsburg Meeting, March, 1910.)

THE Giroux Consolidated Mines Co. is equipping a five-compartment shaft at Kimberly, Nev., which will serve the Alpha mine.

The depth of this shaft, January, 1910, is 963 ft., and of this depth 948 ft. was opened by raising; 15 ft. of sinking was done so that the bearers, collar-set, and three shaft-sets might be installed and concreted, and with this done it was possible to erect the necessary surface-equipment for resuming shaft-timbering on the completion of the raise. The arrangement of the shaft-timbering is shown in Fig. 1.

At the 1,000-ft. level of the Alpha, and 750 ft. SW. from the Alpha shaft, a 14- by 18-ft. station was cut, and a 25-h-p. air-hoist was installed. From here the raising commenced on July 5, 1909. The raise was cut approximately 13 by 21 ft. in area, and supported by timbering with square sets, illustrated in Fig. 2, which shows the division into four compartments. The end compartments, which were used as chutes, had the center girts heavier than in the others on account of the wear from falling rock. The chute-lining was braced by inserting 8- by 8-in. stiffeners parallel to and half way between successive caps. Similarly, the lagging on the wall sides of the cage-way and the compartment for pipes and ladder was stiffened with 4- by 6-in. timbers. In the pipe-and-ladder compartment the chute-stiffeners were reinforced with 8- by 8-in. struts, and as the cage-way was partitioned off by braced lining, there was practically no chance of rock entering the ladder-way in case a chute burst into the cage-way.

Over the two center compartments the last two sets were always bulkheaded with 8- by 12-in. timbers, shown in Fig. 3, and from the lower bulkhead the cage sheave-wheel was suspended. After a round of holes had been blasted and the loose

chute, breakers or platforms of 10- by 10-in. timber were spiked on to the girts, in the manner shown in Fig. 4, at intervals of seven sets. On these breakers the rock piled up and formed its

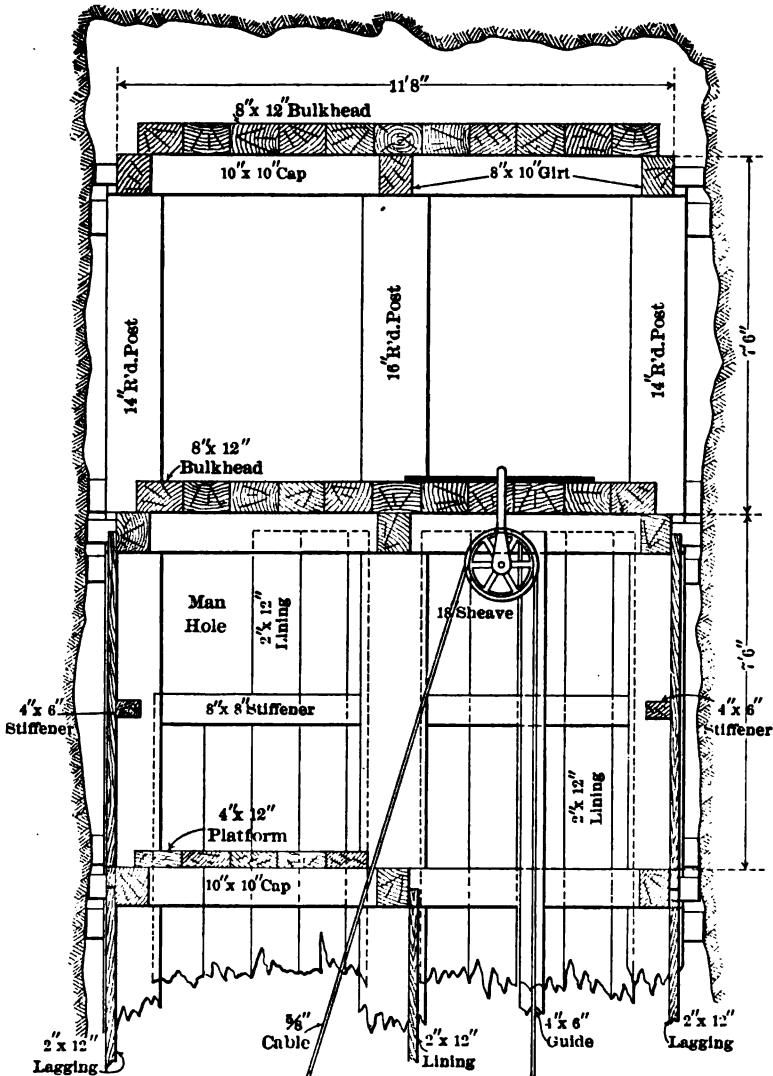


FIG. 3.—PART SECTION THROUGH CAGE-WAY AND PIPE- AND LADDER-COMPARTMENT OF RAISE.

own slope. Trouble was often caused by large rocks dropping into the chute, and on reaching the gate these rocks would have to be drilled and blasted before they could pass through.

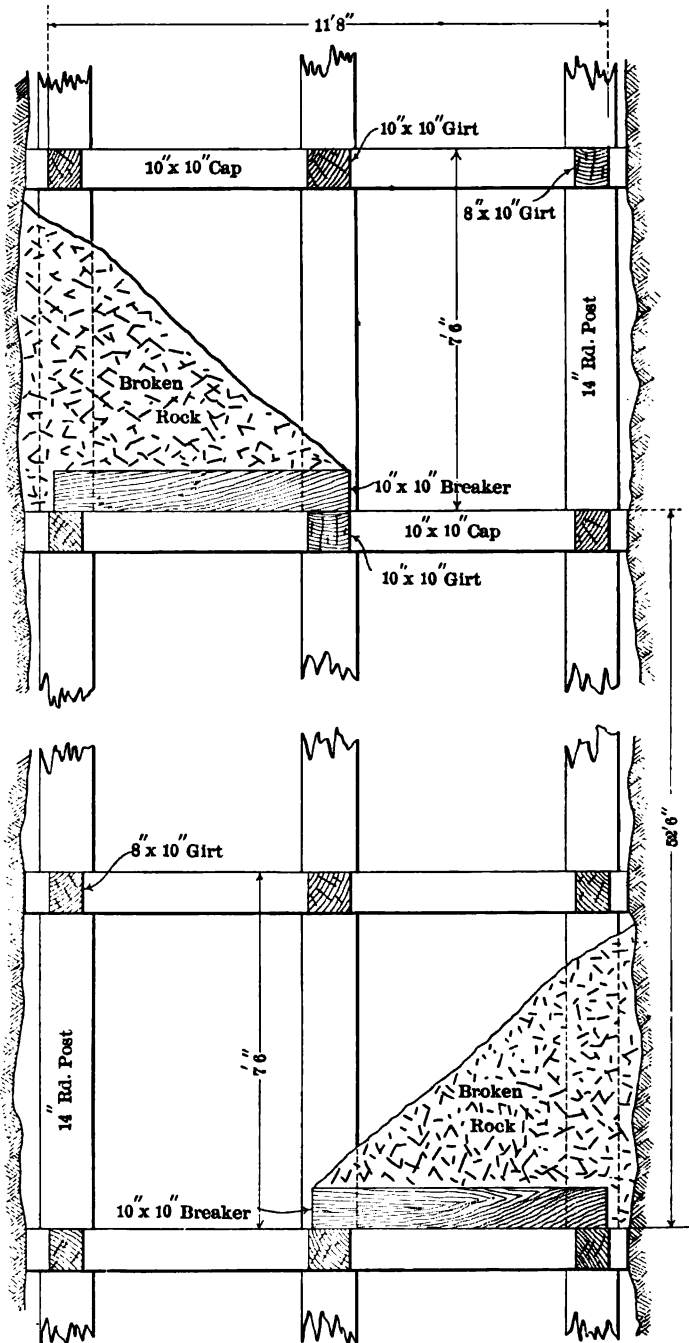


FIG. 4.—DIAGRAM OF SCHEME USED FOR BREAKING FALL OF ROCK IN CHUTE.

The drilling was done entirely with Waugh stopers, No. 8 C, and these machines proved remarkably satisfactory. Three were used for raising the entire distance, one being kept in reserve in case of accident to the others, although all three machines were used on the last 75 ft. of the raise. Each machine wore out one chuck and one tappet, and beyond replacing these, no repairs were required.

The shaft is wholly in limestone, and for the greater part the ground was favorable for fast raising. Normally, on blasting a round of 36 holes 7 ft. deep there would be room for a set of timbers and the back would support itself well. Sometimes the ground was so shattered by intersecting slips that only half the round could be blasted with safety. This procedure made room for half the set, which was then blocked before the remaining holes were blasted and the set completed. At one or two spots the ground encountered could be removed with a pick, and in these cases each post was placed as soon as there was room for it. At 125 ft. from the surface there was a small patch of ground so hard that two rounds of 40 holes were blasted before a set could be placed.

Excellent ventilation was maintained by using two Roots pressure-blowers, size 1, running in tandem. One was placed at the foot of the raise, drawing the foul air through an 8-in. air-pipe and delivering through an 8-in. air-pipe and a 6-in. pump-column to the other blower, which was above ground.

After the 1,000-ft. and 770-ft. levels of the Alpha were connected, the raise was served entirely from the latter level. Three shifts were worked continuously, and 180 days were required to complete the raise, the rate of advance being 5.27 ft. per day, or 158.0 ft. per month.

The progress per month was: July, 167; August, 150; September, 133; October, 143; November, 165; December, 190; total, 948 ft.

The total cost of the raise was \$67,508.89, which is at the rate of \$71.21 per foot, distributed as follows:

	Cost Per Foot.		Cost Per Foot.
Labor: { Raising,	\$16.69	Air-compressor,	\$10.00
Tramming,	5.09	Supplies,	17.24
Timber framing,	1.76	Hoisting,	15.15
Blacksmithing,	1.19	Proportion of general under-	
Machine-shop,	0.11	ground expense,	3.44
Teaming,	0.54	Total,	\$71.21

As the development of the mine proceeds, 75 per cent. of the timber used in this raise will be available for other purposes; hence the raise will eventually be credited with 75 per cent. of the cost of that timber; \$10 per foot of raise represents the timber-cost, so that the true cost of the raise is \$71.21, less \$7.50, or \$63.71 per foot.

The work was performed under the direction of William Hogan, mine superintendent, formerly of the West Stewart mine, Butte, Mont.

I wish here to express publicly my cordial thanks to Frank P. Mills, general manager of the Giroux Consolidated Mines Co., for his courtesy in furnishing the necessary data given in this paper.

The Conditions of Accumulation of Petroleum in the Earth.*

BY DAVID T. DAY, WASHINGTON, D. C.

(Pittsburg Meeting, March, 1910.)

IN 1897 I published a proposed explanation¹ for the variation in color and specific gravity of Pennsylvania oils. A *résumé* of this subject was also presented at the First International Petroleum Congress, in Paris, in 1900. Since that time much experimental work bearing upon this explanation has been carried on by myself, in the United States Geological Survey, and under my direction, by Dr. J. Elliott Gilpin, Marshall P. Cram, and O. E. Bransky, at the Johns Hopkins University. The experimental results thus accumulated seem to throw considerable additional light upon the variations in color and specific gravity of petroleum, as found in different parts of the world, and also upon the variations in chemical composition. Therefore, it seems as if a summary of the evidence thus obtained might be of value to those members of the Institute who are interested in the examination of oil-fields. The summary is here presented for that purpose.

The phenomenon has often been observed in many oil-fields that oils of different color, specific gravity, and chemical composition may be found within short distances of each other. A conspicuous example of this is the occurrence at Jennings, Welsh, and Anse la Butte, La., of petroleum chemically somewhat similar to Russian petroleum; that is, characterized by the presence of naphthenes. Another characteristic is the presence of considerable percentages of asphaltic compounds, sufficient in quantity to disguise the presence of solid paraffin wax, and perhaps also to render that paraffin wax more soluble

* Published by permission of the Director of the United States Geological Survey.

¹ *Proceedings of the American Philosophical Society of Philadelphia*, vol. xxxvi., No. 154, pp. 112 to 115 (January, 1897).

in the oil than it would be were not these asphaltic compounds present. At Belle Isle, La., only 40 miles from Anse la Butte, petroleum is found unusually light in color, about that of sauterne wine. This petroleum is practically free from sulphur, very much lighter in specific gravity than the other oils, free from asphalt, and shows abundantly the presence of paraffin wax in solution. At first glance the oils seem to be entirely different, but chemical examination shows them to be as closely related to Russian oils as are those from Texas, and markedly different from the oils of the paraffin-hydrocarbon series found in Pennsylvania.

Other instances are noted of similar variations in oils within short distances, especially in Mexico, as well as in California, Wyoming, Oklahoma, Texas, and elsewhere. The oils usually, however, contain some characteristics in common, which would indicate that one oil has been derived from the other. In endeavoring to express such a genetic relationship, it has been supposed that the dark oils have been derived from the lighter ones by evaporation and oxidation. In the instance cited for Louisiana, this is evidently not the case, since the dark oil contains much material not found in the light oil, and which never could have been obtained from the light oil by oxidation. I refer to the considerable amount of sulphur present in the dark oil and not in the light oil. If we add to the light-colored oil sulphur compounds and asphalt in appropriate amount, the dark oil is practically reproduced. That the dark oil is not an evaporation-product from the light oil is shown by the fact that it contains hydrocarbons as volatile as those of the light-colored oils, though not in so great a quantity. The proportions of the hydrocarbons present do not admit of working out any probable process of evaporation which would take out some of the heavier constituents of the light oil and leave the percentages of very volatile ingredients which are found. There is, however, no evidence that the light oil may not have been obtained by some process from the darker oil, and long ago the explanation was offered that the lighter-colored oil was produced by some process of distillation from the darker oil. This explanation is practically impossible, inasmuch as the light oil contains heavy paraffin wax, and oils with high boiling-points, while the dark oil also contains volatile oils, which would have

distilled off long before some of the oils found in the light-colored material.

If there is a relation between these two oils, some change has taken place by which oils in solution in the dark, more complex oil, have been left behind, while other ingredients of the dark oil have been separated to form the light-colored product.

In my paper I referred to the observation made in a vaseline factory, that when a black oil containing some pitchy material, very black in color and semi-solid in consistency, is heated so as to be perfectly fluid and is then allowed to diffuse slowly through dry fuller's earth, the first diffusion-product is lighter in specific gravity than the original material. It is perfectly colorless, and remains entirely liquid at the ordinary temperature. On experimenting with this material, it was evident that the lighter oils contained in the original materials diffused more rapidly through the fuller's earth—just as hydrogen will diffuse through a porous medium more easily than oxygen will, and therefore separates itself from oxygen. The idea occurred that crude oils in traversing dry, fine-grained shales in the earth might also diffuse with unequal rapidity, resulting in differential diffusion of the products; that is, fractionation by diffusion. Experiments clearly showed this to be the case with specimens of dried Devonian shale from Pennsylvania.

Clifford Richardson² applied this experiment to Texas oil, and found that sulphur compounds in that oil are left entirely behind by failing to diffuse into fuller's earth.

A long series of experiments undertaken in the U. S. Geological Survey showed that when a glass tube is packed tightly with dry fuller's earth, and one end is allowed to stand for one or two days in crude petroleum, the oil diffusing up through the clay fractionates to a considerable extent. Thus, when the upper fifth portion of the clay is dropped into water, a lighter-gravity oil is driven out by the water. This first fraction is entirely colorless. The lower fractions are heavier and more and more highly colored. The bottom section may be almost solid, and is darker in color than the original oil. The upper portion, although lighter, yields on fractionation some heavier oils and even paraffin wax, but the proportion of lighter oils is

² *Journal of the Society of Chemical Industry*, vol. xxi., No. 5, pp. 316 to 317 (Mar. 15, 1902).

greater than in the original and much greater than in the lowest sample. A fractionation by diffusion has been effected, which is similar to fractionation by distillation, but is not so complete.

It has since been shown by Dr. C. Engler³ that no chemical change is effected in this process, but merely a mechanical separation of liquids from liquids.

It should be noted that when the clay saturated with oil is stirred with water in order to drive out the oil by water, another partial fractionation is effected. The heaviest oil remains in the clay with the water to the extent of a third or a fourth of the entire oil, while the rest leaves the clay.

Another interesting feature of this diffusion is that the oil will not only rise to a height of 5 or 6 ft., for example, in a tube packed with fuller's earth, directly against gravity, just as it does in a wick, but if the tube be sealed at the upper end the oil will still rise in the tube, driving out the air in the pores of the earth and compressing it in the upper portion of the tube with a pressure sufficient to blow out the clay if the top of the tube be suddenly broken off and the air thus released. This effect of capillarity seems to produce pressures similar to those obtained in measuring osmotic pressure—which have been carried to about 40 atmospheres. The most common pressures found in oil- or gas-wells in Pennsylvania and West Virginia agree strikingly well, although occasional natural-gas wells of much higher pressure have been reported.

As stated above, water drives the greater part of the oil out of the clay, though not all. Conversely, oil will not enter wet or even moist clay. In fact, it has already been pointed out by me as well as by L. Mrazec, Director of the Geological Survey of Roumania, that wet, porous rocks are the most impervious cap-rocks for oil, so long as they do not have cleavage-planes in which the space is greater than capillary.

The size of the capillaries is of great consequence in these diffusion phenomena. Finely-divided material, such as amorphous silica, has no observable fractionating-power on oils that are readily fractionated by dry clays. Naturally, ordinary sands neither fractionate nor do they allow water to drive out

³ *Zeitschrift für angewandte Chemie*, vol. xiv., No. 36, p. 889 (Sept. 3, 1901).

oil from them with the same pressure phenomena as are shown in clays.

From these phenomena it is easy to derive a probable method of accumulation of oils in the sandstones of Pennsylvania, if we only assume that dark-colored oil (possibly containing sulphur and asphalt) entered shales varying in fractionating-power, due to varying porosity or moisture. By this means the oil would remain absorbed in the shales without forming an available pool until the entrance of water from any direction had the effect of driving the oil to such places where the expelling action of water is the slightest; that is, in the sandstone layers between the layers of shale. Considering the vastly greater power of capillary action over gravity, it makes no difference whatever whether the water drives the oil up or down. It will expel the oil with greater or less pressure upon the contained natural gas, until there is formed a pool of oil of light or dark color and under greater or less pressure compared with adjoining pools, where the conditions vary with the character of the shales, which vary in moisture and porosity from one acre to another.

The age of the shale has nothing to do with the accumulation process, provided that the shale has had time enough to lose sufficient original water to admit the oil.

Obviously, the locus of the oil pool will be a layer of sandstone, because water has least power for driving it out where the capillaries are large. If, on the other side of the sandstone, the shale is dry, the oil is absorbed and dispersed until it reaches the surface or is hemmed in by wet shale which it cannot enter, for the same reason that it cannot re-enter the shale from which it has just been driven by water. There the oil must accumulate. How long can it remain there? Indefinitely? I think not; for the driest shale was once mud, and if by slow process the shale does not become too dry to hem in the oil, it has all the chances in favor of the formation of minute cracks, which are not oil-tight. These cracks are not oil-tight unless absolutely sealed with water.

It seems very improbable that oil could have existed since Devonian time in the present pools.

These diffusion phenomena make much more probable the proposition advanced many years ago by Dr. John N. Mac-

Gonigle, of Oil City, that the oils are the same as the Ordovician limestone oils of Ohio, with the sulphur removed by diffusion.

One further observation. It was found in my early work, which has since been verified by a long series of quantitative experiments by Gilpin and Cram at Johns Hopkins University,⁴ and again by Herr,⁵ in Russia, that unsaturated hydrocarbons are less diffusible than saturated hydrocarbons even when less viscous than the saturated ones, and hence they are left behind. This seems to explain very satisfactorily the fact that these diffused oils of Pennsylvania are practically entirely saturated oils, in strong contrast to the undiffused oils of California, and many other pools in the United States.

⁴ *Bulletin No. 365, U. S. Geological Survey*, p. 26 (1908).

⁵ *Petroleum*, p. 1284 (August, 1909).

Recent Progress in Blast-Roasting.

BY PROF. H. O. HOFMAN, BOSTON, MASS.

(Canal Zone Meeting, November, 1910.)

I. INTRODUCTION.

THE substance of this paper was prepared for the Seventh International Congress of Applied Chemistry, held in London, May, 1909, under the title, Some Developments in Blast-Roasting. In the absence of the author, a short abstract of the paper was read, and the abstract only will appear in the proceedings of the congress. The present paper has been partly rewritten and considerably enlarged by information gained since the original was prepared; also some illustrations have been added.

Blast-roasting¹ is a generic term for the process of forcing air through finely-divided metallic sulphide with the object of roasting and agglomerating in a single operation. At first the process was confined to a galena-concentrate; lime, limestone, or gypsum was added, to serve both as a diluent to keep separate the particles of galena that they might be thoroughly oxidized, and as a flux that the partly-roasted ore might be agglomerated by the formation of some slag. Later it was extended to treat other metallic sulphides.

The leading processes were the Huntington-Heberlein and the Savelsberg of Europe, and the Carmichael-Bradford of Australia. In the United States and Canada, the Huntington-Heberlein process has found application in some instances with galena-concentrates, for which it was originally intended; but this class of ore is not often treated alone, hence the process has had to be modified to suit conditions. The Savelsberg process has been transplanted to this country in about its original form. The Carmichael-Bradford is not used at present. The changes called for in the Huntington-Heberlein process to adapt it to the class of lead-bearing ores usually smelted have been the

¹ A. S. Dwight, *Engineering and Mining Journal*, vol. lxxxv., No. 13, p. 649 (Mar. 28, 1908).

cause of extending the operation of blast-roasting to other sulphides, especially to concentrates of sulphide copper-ores and to fines of sulphide copper-nickel ores, to prepare them for blast-furnace treatment. Thus an entirely new field has been opened up for the new manner of eliminating sulphur and sintering the roasted product. With it, methods and apparatus have come into use for obtaining a desulphurized porous clinker which are improvements upon those used originally in the three processes.

It is convenient to distinguish between the up-draft and the down-draft apparatus. Of the former, the various forms of the Huntington-Heberlein pot are typical; of the latter, the Dwight-Lloyd roasting-machine is the sole representative found at present in smelting-plants. The object of the present paper is to pass in review the present practice of blast-roasting in the United States and Canada by citing a few characteristic examples with the leading technical facts; the data have been obtained in part from the technical literature, but mostly, however, from the representatives of the works.

II. UP-DRAFT BLAST-ROASTING APPARATUS.

1. *The Huntington-Heberlein Process.*—This process, in a form approaching the original, is in operation at three plants in British Columbia.² The works of the Consolidated Mining & Smelting Co. of Canada, Ltd., at Trail,³ are the most important. Here the Huntington-Heberlein plant was installed in 1906 and enlarged in 1907-08; it consists of eight Huntington-Heberlein mechanical roasting-furnaces and 24 converting-pots. A roasting-furnace has a hearth 26 ft. in diameter, which makes 1 revolution in 3 min., and requires from 2½ to 3 h-p. to run it. There is one fire-box, 6 by 3 ft. in area. The angle of the blades in the stationary rake, and the rate of feeding, are so regulated that the thickness of ore on the hearth is from 4 to 5 in. The ore is a concentrate, which consists mainly of galena, but contains some pyrite and blende; an average assay shows

² W. R. Ingalls, *Report of the Commission Appointed to Investigate the Zinc Resources of British Columbia*. . . , Mines Branch, Department of the Interior, Ottawa, p. 64 (1906). H. O. Hofman, *Mineral Industry*, vol. xv., p. 531 (1906.)

³ Communication by J. Sabarthe, Manager. Papers by A. J. McNab, *Journal of the Canadian Mining Institute*, vol. xii., p. 424 (1909), and L. A. Palmer, *Mines and Minerals*, vol. xxx., No. 8, p. 496 (Mar., 1910).

SiO₂, 28; Fe, 6; Pb, 56; S, 15 per cent.; some Cu; Ag, 65 oz. per ton. The charge is so made up that it will work well not only in the preliminary reverberatory-roast, but also in the blast-roast and in the smelting in the blast-furnace. Under normal conditions, the reverberatory roaster-charge is compounded so as to contain Pb, 40 to 44; Fe, 10 to 13; SiO₂, 8 to 11; CaO, 7 to 10; and Zn, less than 10 per cent. When roasted and converted, the mixture will give a fairly hard and dense clinker of a yellow to grayish-yellow color that is not too tough to be readily broken to the required size; it will also make a small amount of fines. Charges containing more than 45 per cent. of lead have not proved entirely satisfactory, since the percentage of residual sulphur is found to be too high; the cause for which appears to be that some galena fuses before it is roasted. However, it is believed that by using a mechanical mixer to bring the components of the charge into closer contact, a lead-content even higher than 45 per cent. will be permissible. The lowest percentage of lead in the roaster-charge tried so far has been 38; and this has proved to be more satisfactory than 42, since it permits a faster sintering and gives less trouble; it is believed that under the given condition, a charge with from 38 to 40 per cent. of lead will fill all requirements.

As to the relation of iron and silica, experience has shown that the percentage of iron (Fe) ought to be at least equal to that of the silica, and that the charge works more satisfactorily if the percentage of iron exceeds that of silica by 1 or 2 per cent. When the reverse condition obtains there is always trouble in the blast-furnace, even if the elimination of sulphur remain the same, since the tonnage is diminished, the slags become richer in lead, and the heat creeps up in the shaft.

The amount of lime in the charge is allowed to range from 7 to 10 per cent.; it usually varies from 8 to 9 per cent. With less than 7 per cent., the results have been unsatisfactory. However, if with less than 7 per cent. of lime the total of iron and lime is kept about the same and the lead is held at 42 per cent., it is believed that the mixture will be as satisfactory as the one usually made. One disadvantage of a low lime-content is that the blast-roasted material is extremely tough. No charges have been run that exceeded 10 per cent. of CaO.

In rough-roasting, the ore passes through the furnace in 1 hr. 45 min.; the furnace puts through in 24 hr. from 38 to 45 tons of charge with a fuel-consumption of 150 lb. of coal per ton of ore, and an attendance per shift of one-fourth of the time of a fireman and one-half of the time of a wheeler; the rough-roasted ore retains about 7 per cent. of sulphide and 1.5 per cent. of sulphate sulphur. Experience has shown that for a good desulphurization in the converting-pots the ore discharged from the reverberatory furnace should not contain more than 9 per cent. of sulphur.

The temperature must be carefully regulated; if too low, the elimination of sulphur decreases; if too high, the furnace will rapidly become incrustated. If roasted properly the ore has been changed into sintered globules, in which none of the original constituents are discernible.

The elimination of about one-half of the sulphur in this rough-roasting operation is large as compared to the small amounts oxidized when a galena-concentrate low in other sulphides is being treated. Thus Guillemain⁴ has shown that in roasting a pure galena-concentrate with a siliceous gangue, lead sulphide is mainly converted into sulphate, and the main object of rough-roasting such a concentrate previous to treatment in a converting-pot is to reduce its calorific value by changing part of the sulphide sulphur to sulphate sulphur, and thus counteract any premature fusion of the charge.

The converting-pot is 8 ft. 8.5 in. in diameter and 4 ft. 2 in. deep. The grating is made up of four sectoral perforated cast-iron plates, which are bolted together; these sections are preferable to a single casting, as they do not crack so easily because a change in size, due to expansion and contraction, is taken up in the joints. Cast-steel as a material for the grating has not proved satisfactory, since it buckles when heated. A pot takes a charge of from 12 to 15 tons; an analysis of such a charge gave SiO_2 , 10.5; Fe, 10.3; Pb, 42.0; Cu, 1.3; S, 8.5; H_2O , 8 per cent., and Ag, 55 oz. per ton. The water-content of the analysis is exceptionally high; usually it is nearer 5 per cent. The roasted ore is discharged from the furnace into the boot of an elevator, which delivers it through a spray of water into

⁴ H. O. Hofman, *Mineral Industry*, vol. xiv., p. 404 (1905.)

a brick bin, from which it is conveyed in cars to the iron hoppers of the converting-pots. In operating a pot, some slabs of wood are placed in the converter with a shovelful of glowing coals, a gentle blast is turned on until the wood burns freely, and then the charge is dropped through the hopper in the roof. The volume of blast is now increased so as to show a pressure of from 6 to 8 oz.; it is then gradually reduced until, towards the end of the blow, it has decreased to 2 oz., when the fire will have reached the surface of the charge. A charge is blown in 8 hr.; 95 per cent. of the material is in lump-form, leaving only 5 per cent. to be re-treated. An average assay of the coarse product shows Pb and Cu, 44; S, 3 per cent., and Ag, 60 oz. per ton. Since the introduction of the Huntington-Heberlein process, the lead-content of the blast-furnace charge has been considerably increased above the former standard, reaching 40 per cent. of the weight of the charge (ore plus flux). A charge averages 85 per cent. of blast-roasted material, the rest being some oxide lead-ore, siliceous ore, limestone, and foul slag. A furnace, 45 by 160 in. at the tuyere-section, smelts daily 170 tons ore (not charge), and produces from 60 to 70 tons of lead-bullion.

An interesting development of blast-roasting at this plant is the treatment of the regular lead blast-furnace matte, which contains Pb up to 25, and Cu, from 8 to 10 per cent. The matte is granulated while it is being tapped from the fore-hearth, rough-roasted in an O'Hara or a Godfrey mechanical reverberatory furnace, whereby the sulphur-content is reduced to 12 per cent., the roasted matte moistened and blown in a Huntington-Heberlein pot, which usually lowers the sulphur-content to 3 per cent., occasionally to 1 per cent., and furnishes a basic material to be smelted with siliceous ore for a matte with about 42 per cent. of copper. Low-grade copper-matte with Cu, 15; S, 27; and Fe, 56 per cent. is treated in a similar manner.

A cake of blast-roasted matte is usually tough and therefore hard to break. At one plant in the United States this difficulty is in part remedied by spreading a layer of lime when half of the matte-charge has been dumped into the pot, and then covering it with the other half. This layer forms a division-plane along which the blast-roasted matte separates when it is discharged from the pot.

In many instances, blast-roasting of crushed lead-matte has been a failure at the start. The question whether granules and angular grains behave differently in the process has not been satisfactorily answered so far. However, several plants using the Huntington-Heberlein pots have succeeded in obtaining satisfactory results with matte. It thus appears that the difficulties encountered at first have been overcome.

The American Smelting & Refining Co., which owns the patents of the Huntington-Heberlein process for the United States, has introduced this method of blast-roasting in all of its lead-smelting plants, but with modifications necessitated by local conditions.

In treating a galena-concentrate, the mode of operating is comparatively simple, as the presence of a large amount of oxidized lead makes the scorification of the gangue relatively easy. Thus at East Helena, Mont.,⁵ the leading ore is a galena-concentrate from the Cœur d'Alène district, Idaho, which assays⁶ from 47 to 55 per cent. of lead and forms an easy charge for the 12 converter-pots which are in operation at present. When, however, charges are to be treated in which the lead-content is not to exceed 20 per cent., the matter assumes a different aspect, as besides a correct chemical composition of the mixture, its physical character becomes of decided importance. Thus, as a rule, a considerable amount of systematic experimenting becomes necessary before a suitable charge is obtained; it also takes some time before the required experience has been gained to know how to handle a given charge. Further, in a custom plant which treats ores from different sections of the country, the character of the ores received often undergoes changes sufficiently great to affect the result of blast-roasting, the percentage of sulphur eliminated becoming too small, or the amount of fines produced too large. Hence the working of the Huntington-Heberlein process becomes complicated and is not always attended by uniform results.

The practice at the different works of the American Smelting & Refining Co. is not the same. The Murray plant, near

⁵ *Engineering and Mining Journal*, vol. lxxxvii., No. 7, p. 350 (Feb. 13, 1909).

⁶ J. P. Rowe, *Mining World*, vol. xxx., No. 10, p. 428 (Mar. 6, 1909).

Salt Lake City, Utah,⁷ built in 1901, is the largest lead-smeltery of the company. The introduction of the Huntington-Heberlein process in 1905 has changed the character of the blast-furnace work to this extent, that a furnace, 48 by 168 in. at the tuyere-section, using from 12 to 15 per cent. of blast-roasted ore, puts through 200 tons of charge in 24 hr. instead of 160 tons, and that the charge contains a larger percentage of ore than formerly. The plant contains five Godfrey mechanical roasters, 26 ft. in diameter, which work on the same principle as the Huntington-Heberlein roasting-furnaces, noted above. A roaster puts through in 24 hr. about 30 tons of ore containing from 18 to 25 per cent. of sulphur and reduces the sulphur-content to from 8 to 12 per cent., with an outlay of about 130 lb. of coal per ton of ore. The 14 Huntington-Heberlein pots of standard size, 9 ft. in diameter, are placed in a single row and are served by a 30-ton overhead electric traveling-crane; there is room on the opposite side of the building for a second row of 14 pots. A pot receives a charge of about 9 tons, and treats it on the average in 12 hr. A charge is made up of raw ore (S, high; SiO₂, 40; FeO, 20 per cent.) and roasted ore (S, 8 to 12; SiO₂, 10; FeO, 20 per cent.) in proportions to keep the lead between 18 and 20, the zinc under 10, and the sulphur between 16 and 20 per cent. In charging, there is first given a layer of ashes to protect the grate, this is followed by about 1 ton of hot roasted ore containing about 8 per cent. of sulphur, then comes another ton of similar ore with about 12 per cent. of sulphur, and lastly 7 tons of moistened mixture of raw and roasted ore, the water added being sufficient in amount to cause the particles to cohere when squeezed in the hand. The blast-pressure reaches 25 oz. and the sulphur-content is reduced to 4 per cent. The top of a blown charge is always made up of imperfectly desulphurized powdery material, which goes into another pot beneath the moistened ore-mixture. A blown pot is raised by means of the overhead crane, tilted to pour off the dusty fines, transferred to the breaking-platform at one end of the building, inverted, and the solid cake dumped on to conical

⁷ W. R. Ingalls, *Engineering and Mining Journal*, vol. lxxxiv., No. 12, p. 527 (Sept. 21, 1907); No. 13, p. 575 (Sept. 28, 1907). R. B. Brinsmade, *Mines and Minerals*, vol. xxviii., No. 5, p. 216 (Dec., 1907). H. O. Hofman, *Mineral Industry*, vol xvi., p. 665 (1907).

castings placed on the floor, which is laid with closely-set rails; large pieces are raised by means of the crane and dropped again; smaller ones go direct to a 10- by 20-in. Blake crusher, which discharges on to a conveyor.

The usual Huntington-Heberlein pot is 9 ft. in diameter and 4 ft. 6 in. deep. It is a single casting, which has in the bottom an air-pipe 5 in. in diameter; the height of the sectoral grate is 15 in.; the conical holes in the four, six, or even eight sections which make up the grate are $\frac{3}{8}$ in. in diameter. There is a tendency to improve upon the established form and thus do away with imperfections discovered in practice. The modern form of pot is larger and shallower than the older; a pot is 11 ft. in diameter and 3 ft. deep to top of grate, and takes 15 tons of a 50-per cent. lead charge instead of 8 or 9 tons. It is cast in four flanged sections, which are bolted together, and the bowl thus formed is bolted to a very flat bottom, the joints being made tight by an asbestos-cord packing. The life of a kettle is greatly increased by using sectional casting, a pot cast singly often cracking in the most unexpected manner.

The manipulation of the pots at the Murray plant is a great improvement upon the older method of dumping by means of worm-gear or lever.

The charging arrangements have also been brought up to modern standards of mechanical handling of materials.

2. *The Savelsberg Process.*—This process is used by the St. Joseph Lead Co., Flat River, Mo.,⁸ for desulphurizing and agglomerating a non-argentiferous galena-concentrate resulting from the dressing of ore which occurs in dolomitic limestone. There are in operation 18 pots, placed in two rows. A pot is 8.5 ft. in diameter and 4.5 ft. deep; it treats in from 10 to 12 hr. a charge of 10 tons of a mixture having the following composition: SiO₂, 13.12; FeO, 5.90; CaO, 6.60; MgO, 3.30; Pb, 47.40; Zn, 2.10; S, 11.20; and H₂O, 6.00 per cent. The mixing of the charge is done mechanically⁹; the charge is delivered by a conveyor-belt to the boot of an elevator, which discharges into a bin above the charging-floor, from which the pots are filled by hand. The blast-pressure in the converting-pot is 10 oz. at the start, it is raised to 20 oz. during the blow, and in-

⁸ Communication by O. M. Bilharz, Consulting Engineer.

⁹ *Engineering and Mining Journal*, vol. lxxxix., No. 13, p. 648 (Mar. 26, 1910).

creased to 25 oz. towards the end; the amount of air used is from 1,000 to 1,500 cu. ft. per min. The finished charge contains from 10 to 15 per cent. of fines, which have to be re-treated. The solid cake is dumped and broken by hand. An analysis of the broken material is SiO_2 , 17.20; FeO , 9.00; CaO , 7.00; MgO , 4.00; Pb , 44.20; Zn , 3.80; and S , 2.30 per cent.

3. *Other Processes.*—At the Tintic Smelter, near Salt Lake City, Utah,¹⁰ F. G. Kelley has substituted for the hemispherical pot a tilting tray-shaped steel vessel, 8 ft. long by 4 ft. wide by 14 in. deep, which holds a grate with $\frac{3}{8}$ -in. holes and ribs to form sections 12 by 14 in. There is an under-grate blast and a movable hood. The tray receives, as a primer, 500 lb. of rough-roasted sulphide ore, and as a charge 3,000 lb. of mixed sulphide ore; the whole is blown in about 4 hours.

At the plant of the United States Smelting, Refining & Mining Co., at Bingham Junction, Utah,¹¹ there were in operation several Robinson blast-roasters. These have been replaced¹² by 20 so-called "roasting-boxes," of which 19 serve for ore-treatment and one for the supply of the primer for starting the ore-charges. A roasting-box has a hearth, 6 ft. square and 3 ft. deep, the bottom of which is made up of cast-iron plates perforated by $\frac{3}{8}$ -in. holes, the sides are of fire-brick, and the hopper-shaped roof is of sufficient capacity to hold a 6-ton charge. The hearth forms the top of the wind-box, through which air is forced from a blower. At the back of the furnace is a door, 12 by 18 in., for the admittance of an electrically-driven ram, which pushes the roasted and clinkered cake out of the front through a sliding door, the upper part of which has a slot, closed by a slide, to furnish access to the furnace for leveling the charge and for closing blow-holes. The ram, similar to the one ordinarily used in discharging coke from horizontal retort coking-ovens, stands on an electric car and travels on a track parallel with the battery of 19 blast-roasters. The ore-charge consists of 33 parts of concentrates, from 5 to 10 of flue-dust, and from

¹⁰ Communication by M. J. Connolly.

¹¹ W. R. Ingalls, *Engineering and Mining Journal*, vol. lxxxiv., No. 12, p. 527 (Sept. 21, 1907); No. 13, p. 575 (Sept. 28, 1907). H. O. Hofman, *Mineral Industry*, vol. xvi., p. 668 (1907).

¹² Private communication by G. W. Heintz, General Manager. Paper by C. T. Rice, *Mines and Methods*, vol. i., No. 1, p. 6 (Sept., 1909).

62 to 57 of fine ore. The composition of the ore is given in Table I.

TABLE I.—*Composition of Ore.*

Kind.	SiO ₂ . Per Cent.	Fe. Per Cent.	CaO. Per Cent.	S. Per Cent.	Cu. Per Cent.	Pb. Per Cent.	Zn. Per Cent.
Richmond fines,	7.0	32.0	7.5	0.8	0.1	4.0	5.0
Centennial Eureka, "L"							
fines,	70.0	6.4	4.0	0.7	1.2	3.5	0.6
Centennial Eureka, "O"							
fines,	71.6	6.1	3.4	0.5	1.8	0.5	0.9
Lead-plant flue-dust, . .	20.0	17.0	6.0	4.5	1.0	19.0	3.0
Bag-house dust, . . . . .	.....	.....	.....	8.0	.....	48.0	6.3
U. S. concentrates, . . .	4.6	19.4	2.0	33.7	1.0	19.1	4.8
U. S. concentrates, . . .	4.0	23.3	2.0	34.2	0.8	17.9	11.6
U. S. concentrates, . . .	5.2	22.2	2.0	34.0	1.0	20.6	14.6
U. S. concentrates, . . .	4.4	25.2	2.0	33.5	1.0	18.9	9.7

The mixture is calculated to contain: S, 19; SiO₂, 28; Fe, 18; Pb, 13; and Zn, 6.5 per cent. The limit of coarseness of the individual particle is $\frac{1}{2}$ in. The different ores are transferred to a Smith concrete-mixer and about 10 per cent. of water is added. The moistened mixture is then transferred to a bin by means of an elevator and thence charged into the hoppers of the roasting-boxes. The primer-mixture is made up of one part impure-blende concentrate, one part bituminous coal, and one and one-half parts of coke-screenings; the concentrate assays: Zn, 30.4; Pb, 6.8; Cu, 1.6; Fe, 12.7; S, 31.7; SiO₂, 7.6 per cent. (Au, 0.06, and Ag, 4.2 oz. per ton). The quantity necessary for an ore-charge is placed on the hearth of the 20th roasting-box, which is kept in operation more or less continuously, brought to a red heat by turning on the under-grate blast, and then transferred to the ore-roaster. At first, however, the grate is covered with a layer of limestone or siliceous ore to a thickness of about 2 in., then follows the red-hot primer, making a cover about 1.5 in. thick, and on top of this comes the charge of 6 tons of ore, which when leveled makes a bed about 26 in. thick. The doors of the furnace are now luted and blast is turned on to give a pressure of 2 oz.; the pressure is gradually increased until the end of the blow, when it reaches 9 oz., the blow lasting from 5 to 8 hr. During the working of a charge, the temperature is kept as low as possible in order to keep down the loss of lead and silver; the progress

of the blast-roast is watched through the slide in the front door. When no more sulphur-fumes are given off, and the roast is finished, the sintered cake is pushed into a sheet-steel boat by means of the ram, and then sprayed with water to cool the clinker and to wash off the fines. The boat is brought by means of a traveling electric crane to a 24- by 36-in. Farrel crusher set to 6 in.; after crushing, the clinker is hauled to the stock-bins of the blast-furnace. The 19 roasting-boxes treat about 320 tons of charge per day; the elimination of sulphur from ore-charges ranges from 65 to 70 per cent.; from matte-charges the average expulsion is only 37 per cent.; matte is therefore roasted in reverberatory furnaces. The loss in lead and silver averages 4 per cent. The plant is served, per shift, by 1 boss, 1 ram-man, 5 pot-men and 2 men charging the ore to the bins and hoppers, or 9 men in all. The cost of treatment is \$1.25 per ton of ore.

4. *Blast-Roasting of Sulphide Copper- and Copper-Nickel Ores in Pots.*—The changes in the Huntington-Heberlein process for treating lead-ores that were made necessary by the great variety of ores that have to be treated in a custom plant, led to the discovery that lime, although very desirable, as it increases capacity and gives a better product, was not necessary for the successful blast-roasting of lead-ores, and that it could be omitted entirely provided that the other components of the charge were correctly apportioned. This was the cause of W. R. Ingalls's term of "lime-roasting"¹³ being in part replaced by L. S. Austin's designation of "pot-roasting."¹⁴ The next step was to experiment with sulphide copper- and copper-nickel ores. In some cases the work has been successful, in others not. The main cause of this difference in results appears to lie in the physical character of the ore-charge. Slight changes in the chemical composition and the size of the ore-particles, which would hardly be noticed in a lead-charge, make the difference between success and failure in a copper-mixture. Fine concentrates, even when diluted with coarse ores, are liable to cause trouble. Copper-concentrates with an admixture of about 10 per cent. of flue-dust appear to work better

¹³ *Engineering and Mining Journal*, vol. lxxx., No. 10, p. 402 (Sept. 2, 1905).

¹⁴ *Mining and Scientific Press*, vol. xciii., No. 17, p. 511 (Oct. 27, 1906).

the sulphur-content to about 17 per cent. There are 25 converting-pots of the standard Huntington-Heberlein form; a pot treats 8 tons in 8 hr. The kindling-charge consists of 1 ton of hot calcines, the remaining 7 tons are cold calcines containing about 5 per cent. of water, and assaying Cu, 8, and S, 17 per cent. The blast-pressure at the start is 6 oz.; it is increased during the run to 25 oz. and diminished towards the end to 20

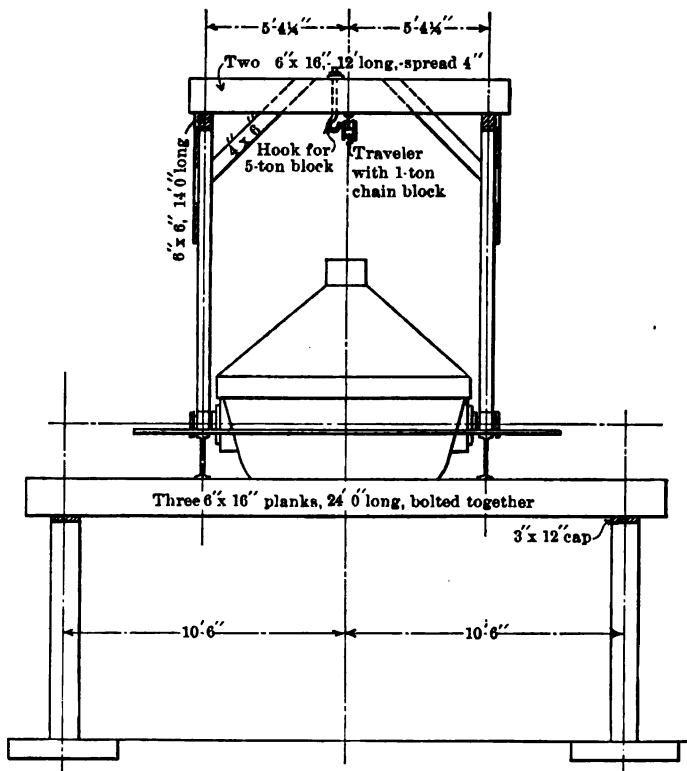


FIG. 2.—FRONT VIEW OF EXPERIMENTAL BLAST-ROASTING APPARATUS OF DETROIT COPPER MINING CO.

oz. The sulphur-content is reduced to 6 per cent., but from 40 to 50 per cent. of the weight of the charge has retained its original finely-divided character. Taking into consideration that the best metallurgical talent is at the disposal of this company, the difficulties with this class of ore in a Huntington-Heberlein pot appear to be very great.

(b) The Detroit Copper Mining Co. of Arizona, Morenci,

Ariz.¹⁶ At these works sulphide copper-ore and flue-dust were blast-roasted for some time in spherical kettles. While the work was satisfactory from a purely metallurgical point of view, economic considerations were the cause of giving up the process. Some of the details, however, have permanent interest. The general arrangement of the plant is shown in Figs. 1 and 2; details of construction of the pot are given in Fig. 3. In Fig. 1 the pot is seen to rest with its trunnions on supports which are carried by two steel beams; these rest with one end on the solid rock and with the other on three planks bolted together, and they in their turn are supported by two columns. During a blast, the pot is held in position by four supports and a bearing-ring, Fig. 3. When a charge is finished, the hood is lifted with a 1-ton chain-block and conveyed to the position indicated by the dotted lines in Fig. 1, then the pot is tilted by means of a 5-ton differential chain-block, the cake falls to the ground, and is there broken by hand and shoveled into cars. The details of the construction of the pot and the grate are evident from Fig. 3.

The charge treated in a pot weighed 10 tons; it was made up of 8 tons of concentrate and 2 tons of flue-dust. A screen-analysis of the concentrate gave the following:

	Per Cent.
On $\frac{1}{2}$ -in. opening,	3.3
Through $\frac{1}{2}$ -in. and on 10-mesh,	9.6
Through 10-mesh and on 40-mesh,	30.9
Through 40-mesh and on 80-mesh,	25.5
Through 80-mesh and on 120-mesh,	14.0
Through 120-mesh and on 200-mesh,	7.8
Through 200-mesh,	8.9
	100.0

A chemical analysis gave the subjoined constituents: SiO_2 , 14.3; Fe, 24.9; Al_2O_3 , 5.0; CaO, 0.5; MgO, 0.5; S, 32.2; Cu, 18.8; difference, 3.8 per cent. The moisture in the concentrate as used averaged 8.5 per cent. Flue-dust gave upon analysis: SiO_2 , 23.9; Fe, 25.9; Al_2O_3 , 5.5; CaO, 1.9; MgO, 0.5; S, 16.2; Cu, 17.1; difference, 9.0 per cent. As the plant has no roast-ing-furnaces which would furnish hot material to serve as a primer, the usual procedure had to be changed. The grate was

¹⁶ Communication by L. R. Wallace, Metallurgist.

covered with a layer of ashes 0.75 in. thick, a small fire of waste and wood was started in the center and then, when burning well,

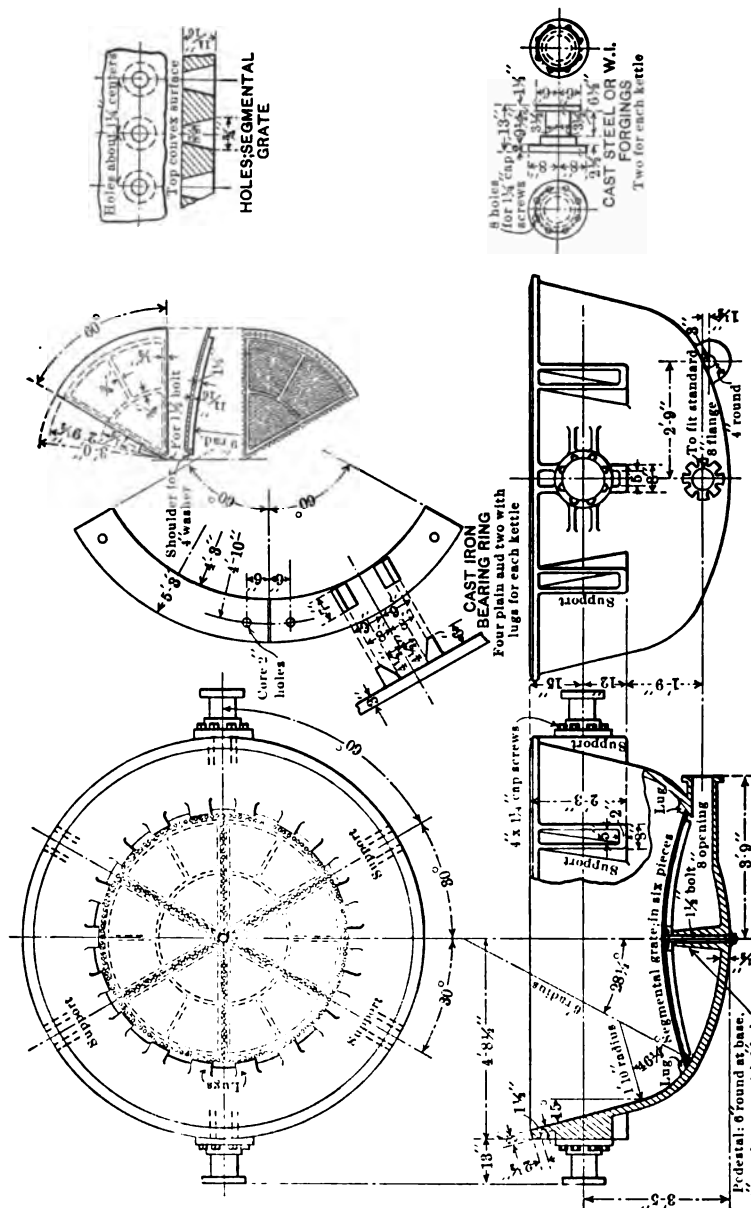


FIG. 3.—DETAILS OF CONSTRUCTION OF THE ROASTING-POT OF THE DETROIT COPPER MINING CO.

75 lb. of saw-dust was fed in such a way as to be about 6 in. deep at the center and to taper towards the periphery. Now a

charge of 2 tons of warm (80°C.) flue-dust was given, and this was followed by a 3-in. layer of concentrate; the blast was started with a pressure of about 2 oz. and allowed to act for 30 min., which was sufficient to kindle the concentrate thoroughly. Next the air-valve was opened full, giving a pressure of about 18 oz., and the concentrate was fed in as fast as the heat crept up. A charge of 2 tons of flue-dust and 10 tons of concentrate required 20 hr. for treatment; one of equal parts of flue-dust and concentrate, 14 hr. The best results gave 93 per cent. of coarse material, which upon analysis showed: SiO_2 , 17.6; Fe, 34.5; Al_2O_3 , 5.8; CaO , 0.8; MgO , 0.6; S, 9.5; Cu, 21.4; difference, 9.8 per cent.

(c) The Canadian Copper Co., Copper Cliff, Ont.¹⁷ At these works copper- and nickel-bearing pyrrhotite is roasted in heaps, the roasted ore is smelted in blast-furnaces, and the resulting matte brought forward in barrel-converters to 80 per cent. of nickel-copper. There are no roasting-furnaces to treat the fines made in breaking the ore, which are usually charged raw into the blast-furnace with the heap-roasted ore. Experiments with pot-roasting were successful, but the process was not carried further, as in the roast-yard there were no mechanical appliances, and working by hand made the cost of treatment too high. The pot used was 8 ft. 6 in. in diameter and 6 ft. deep; the arched grate, with $\frac{3}{4}$ -in. holes, was 2 ft. above the center of the kettle. Two classes of ore, both 0.5 in. and smaller, were treated, viz., Cream Hill fines, and a mixture of 4 volumes of Creighton ore with 1 volume of flue-dust. A pot received a charge of 5.75 tons of Cream Hill fines, which assayed SiO_2 , 31; Fe, 19; CuNi, 6.15; S, 10; H_2O , about 1; while 6 tons of mixture, also with about 1 per cent. of water, could be worked in a single operation. The Creighton ore assayed SiO_2 , 15.5; Fe, 42; CuNi, 6.6; and S, 26 per cent.; the flue-dust, SiO_2 , 23; Fe, 7.3; CuNi, 6.8; and S, 8 per cent. The mode of operating in both cases was the same. Kindling is distributed over the grate to cover an area 2 ft. 6 in. in diameter; on top of this 2 pails of coke-breeze are spread in a layer about 1 ft. in diameter; the wood is ignited, half-blast turned on until the coke is well kindled, ore-charging begun, and then full blast is turned on.

¹⁷ Communication by D. H. Browne, Metallurgist.

When the ore begins to burn in the center, the coke is worked towards the periphery to draw outward the fire and thus ignite the ore outside of the central area. When a good layer of ore has been well kindled, the pot is filled with the rest of the charge. About 7,500 cu. ft. of air is blown in per minute at a pressure of 15 oz.; the time of working is 8.30 hr. The pot-roasted Cream Hill ore retained 2.75 per cent. of sulphur and gave from 15 to 20 per cent. of fines; the Creighton mixture of ore and flue-dust, 12 per cent. of sulphur and from 20 to 25 per cent. of fines.

III. DOWN-DRAFT BLAST-ROASTING APPARATUS.

Blast-roasting with up-draft pots is accompanied by several disadvantages. The leading ones are: (1) the ore is exposed for a long time to the influence of hot gases, and this with lead-ore means loss of metal; (2) the process is intermittent; (3) the pot requires more or less constant attention in filling, blowing, and discharging; (4) the amount of fines that has to be re-treated is liable to be large; (5) the handling of fines causes much loss by dusting; (6) the cake is unevenly sintered; (7) the breaking of the cake is expensive, even when done mechanically, and it is unhealthy if done by hand. Thus the cost of the Huntington-Heberlein process in treating lead-ores is calculated by Ingalls¹⁸ at \$2.16 per net ton of blown mixture, or \$2.70 per net ton of ore. This figure is somewhat high; deducting for blown mixture one-third for the Rocky Mountain plants, and one-half for the Mississippi Valley region, comes nearer to the actual facts. These disadvantages appear to have been overcome by the Dwight-Lloyd sintering-process and apparatus, in which the ore is exposed only for a short time to the influence of heat and blast; that is, approximately 1 min. for each 1 per cent. of sulphur; the process is continuous, and when once adjusted requires little or no attention; it makes very little fines and furnishes a porous sinter of coke-like structure, which usually is small enough to go direct to the blast-furnace.

Three types¹⁹ of sintering-machines are at present in operation: the drum-machine, the straight-line machine, and the horizontal-table machine. All embody the same three func-

¹⁸ *Trans.*, xxxvii., 641 (1907).

¹⁹ Communication by A. S. Dwight.

tions: (1) a layer of ore is spread mechanically to the thickness of from 2.5 to 5 in., average 4 in., on a traveling herring-bone grate; (2) the ore-stream thus formed passes first under an igniter, placed at right angles to the grate, to become ignited at the surface, and then over a stationary suction-box, which by down-draft causes the roasting started at the surface to progress downward and be finished when the ore reaches the farther end of the section-box; (3) the sintered ore is discharged automatically in a size suitable for blast-furnace treatment. A Dwight-Lloyd shallow tray²⁰ using down-draft, but working intermittently, is in operation at the works of the Cerro de Pasco Mining Co., Peru, for desulphurizing mixtures of sulphide copper-ore and flue-dust.

1. The drum-machine,²¹ shown in Fig. 4, consists of a horizontal cylinder, 11 ft. 4 in. in diameter and 3 ft. face, made up of a pair of circular rims of iron carrying cast-iron herring-bone grates with an effective width of 30 in.; the drum-shaped structure rests on two pairs of friction-rollers, one of which is connected with the power. Inside the drum is a stationary suction-box, which occupies the top quadrant of the circle. The ore, fed mechanically upon the rising grate, is ignited, as shown in the illustration, by gasoline-jets, travels over the suction-box in about 20 min., and is discharged automatically from the grate-surface by the points of an upturned grizzly. One experimental machine at the works of the American Smelting & Refining Co., Maurer, N. J., treated, without addition of lime, 50 tons of galena-concentrate, with Pb, 50 per cent., at the rate of 30 tons in 24 hr., with a 4-in. layer of ore, a vacuum of 4 oz., and a power-consumption of 12 h-p. The sulphur-content was reduced to 3.4 per cent., and gases filtered through the bags showed the loss in metal to be less than 0.5 per cent.

This same machine is now installed at the works of the Baltimore Copper Smelting & Rolling Co., Baltimore, Md., for treating, at intervals, mixtures of sulphide copper-ore concentrates and flue-dust at the rate of 25 tons per 24 hours.

In general, it may be stated that the revolving drum consumes from 0.75 to 1.5 h-p.; the fan, from 10 to 20 h-p.; the

²⁰ *Mining and Scientific Press*, vol. xcvi., No. 5, p. 195 (Jan. 30, 1909).

²¹ *Engineering and Mining Journal*, vol. lxxv., No. 13, p. 649 (Mar. 28, 1908).
Mineral Industry, vol. xvi., p. 380 (1907).

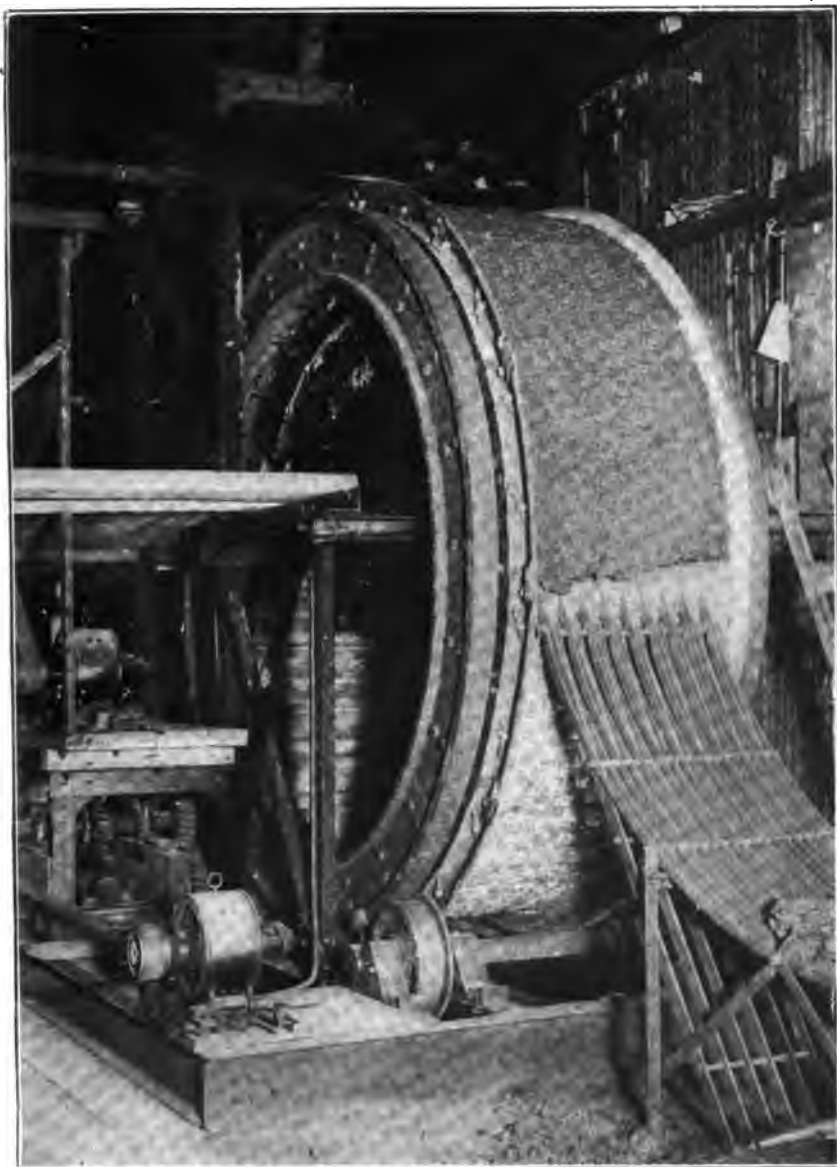
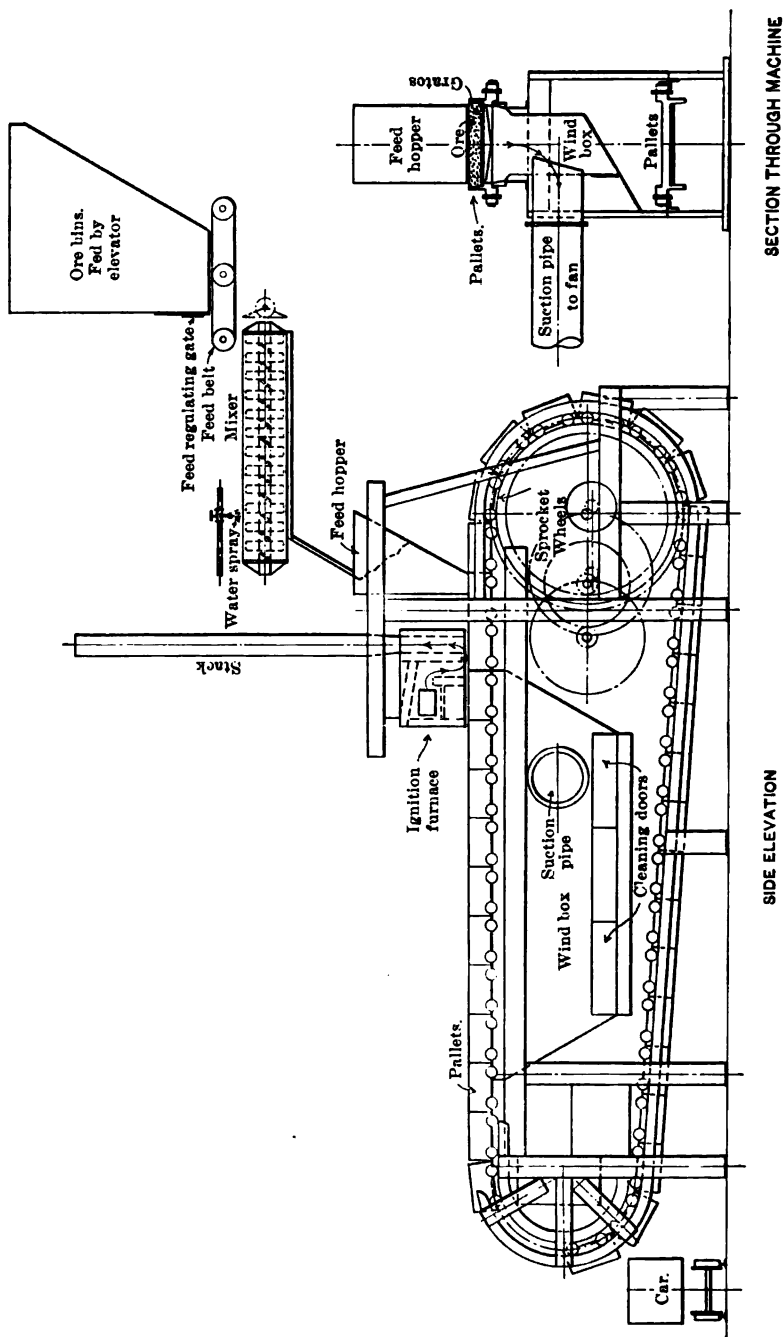


FIG. 4.—DRUM-FORM OF DWIGHT-LLOYD BLAST-ROASTING APPARATUS, SHOWING
UPTURNED GRIZZLY FOR REMOVAL OF SINTERED PRODUCT.



SIDE ELEVATION

SECTION THROUGH MACHINE

FIG. 5.—STRAIGHT-LINE DWIGHT-LLOYD BLAST-ROASTING MACHINE.

mixing, elevating and conveying apparatus, from 4 to 5 h-p., giving a total of from 15 to 25 horse-power.

2. The straight-line machine, shown in Fig. 5, consists of a frame of structural steel supporting a feeding-hopper, an igniting furnace, a suction-box, and a pair of endless-track circuits to accommodate a train of small truck-like elements called pallets which, in combination, form practically an endless conveyor, with the continuity broken at one place in the circuit. Each pallet is provided with four wheels, which engage with the tracks or guides at all parts of the circuit, except when the pallet is passing over the suction-box, and then the pallet slides on its planed bottom over the planed top of the suction-box, thus making an air-tight joint. A pair of cast-steel sprocket-wheels, turning inside of concentric guide-rails, lift the train of pallets from the lower to the upper track by engaging their teeth with the roller-wheels, and launch each pallet in a horizontal path under the feed-hopper and igniting-furnace, and over the suction-box. In a train of pallets in action, all the joints are kept closed, and air-tight, by the pallet being pushed from behind. At the beginning and the end of the track formed by the planed top of the suction-box, there is a planed "dead-plate" over which the pallets must glide; it serves to prevent any leakage of air. After a pallet passes over the suction-box and terminal dead-plate, its wheels engage the ends of the circular discharge-guides. These are adjusted with the view of raising the pallet about 0.5 in. vertically and thus automatically prying up the cake of sinter and freeing it from the grate-slots. A "breaking-roller" prevents the prying action from extending too far back, and tends to form a line of fracture. This roller, however, is not essential in all cases. On reaching the curve of the guides, the pallets one by one drop into the guides, each strikes the pallet which has preceded it and, at the same time, discharges its load of sinter-cake, and shakes free the slots of the grates. The force of the blow can be regulated by the gap left in the train of pallets at this point. The weight of the train keeps the pallets fed down to the lower teeth of the sprocket-wheels.

The igniter frequently used with this machine is a small coal-burning furnace built of tiles, having a grate-area of 10 by 30 in. and burning 500 lb. of coal in 24 hr. The flame after passing over the fire-bridge is deflected downward upon the ore by a

brick curtain that can be raised and lowered, and then is drawn upward by the natural draft of a small stack or bleeder.

The suction-box on top is 12 ft. 6 in. long and 30 in. wide, and gives for the grates an effective hearth-area of 31.25 sq. ft.; this is the true measure of the capacity of the machine. The pallets are each 30 in. wide by 18 in. long and weigh with grates 550 lb.

The power delivered to the machine has its speed-factor reduced by passing through a train of gear-wheels, the last of which engage the internal gear-teeth cast in the large sprocket-wheels, and actuate the train of pallets.

The complete cycle of operations is as follows: A pallet, being pushed onward tangentially from the top of the sprocket-wheels, passes under the feed-hopper, where it takes its load in the form of a continuous even layer of charge, say 4 in. thick, passes next under the ignition-furnace, where the top surface is kindled, and at the same time comes within the influence of the downward-moving currents of air, induced by the suction-draft; these carry the sintering action progressively downward until it reaches the grates. The roast-sintering operation is complete, the cake is discharged by dropping into the discharge-guides, and the pallet crowds its way back to the sprocket-wheels, is slowly raised to the upper tracks, and begins a new cycle.

A straight-line machine of the size described with effective area of 31.25 sq. ft. weighs, without accessories, approximately 16 tons.

At the works of the Ohio & Colorado Smelting & Refining Co., Salida, Colo.,²² the machine in operation is 30 ft. long; the distance between the deflecting brick curtain of the igniter and the surface of the ore is 2 in.; the rate of travel of the pallets is 8 in. per min. The ore-mixture comprises ores of the company of the following composition:

Kind.	Ag. Oz. Per Ton.	Au. Oz. Per Ton.	Pb. Per Cent.	Cu. Per Cent.	Insol. Per Cent.	Fe. Per Cent.	Zn. Per Cent.	S. Per Cent.
New Monarch, . . .	?	?	3.0	none	50	14	9	18
Flue-dust,	17.7	0.46	17.4	1.4	25.4	17.8	4.5	5.9
Sulphide concentrate, .	?	?	23.5	none	6.2	19.8	10.2	23.6
Siliceous ore fines, .	25	3.0	5	none	65	8	?	6
Leadville oxide fines, .	10	.....	3	none	12	48	.....	1

²² Communication by M. J. Connolly.

A typical charge for the machine by weight is: New Monarch, 40; flue-dust, 15; sulphide concentrate, 30; siliceous and oxide ore, 15 per cent.; this brings the SiO_2 content to about 35 and the S to 17.7 per cent. In working, it was found that the largest permissible size of ore-particle was 0.25 in., and that the quantity should not exceed 25 per cent. of the charge. The sintered material retains 4 per cent. of sulphur. The machine treats 50 tons of mixture in 24 hr.; the suction in the chamber shows a vacuum of 6 oz.; the igniter consumes 1,000 lb. of coal per 24 hr.; 1 man attends the machine, but can look after several; the cost of treatment, including bringing the ore 200 ft. and moving sinter a similar distance, is \$0.75 per ton.

Two machines of this type are in operation at a lead-smelting plant in Illinois, where the cost of treatment at the rate of 100 tons in 24 hr. is less than \$0.50 per ton. Other machines are doing satisfactory work in the Mississippi valley. At East Helena, Mont., raw matte from the lead blast-furnace is successfully worked by the machine, the matte forming 62 per cent. of the weight of the charge.

In general, it may be said that a machine treating from 35 to 40 tons of copper-lead ores per day requires, for mixing of charge and propulsion of pallets, from 3 to 6, for the fan 12 to 20, or a total of from 15 to 26 h-p. When treating a galena-concentrate, averaging 50 per cent. of lead in the mixture, at the rate of 60 tons of charge per 24 hr., the power required has been found to be less; for mixing and propelling from 2 to 3, for the fan from 10 to 13, or a total of from 12 to 15 horsepower.

3. The horizontal-table machine resembles a horizontal rotating picking-table, in which the ring-shaped table is replaced by herring-bone grates. The outer diameter is 15 ft., the inner 8 ft., giving a total grate-area of 126 sq. ft., of which about 50 per cent. is effective. The table makes about 1 rev. in 45 min. There is a stationary feed-hopper and igniter; the sinter is removed by means of a scraper and a deflecting-apron. This type of machine has been tried under a variety of conditions, ranging from medium-grade lead-ore and flue-dust to fine copper sulphide concentrate, and has given good results. It is a convenient form for a large unit, but it has the great dis-

advantage that the scraper in removing the sinter forces an undue amount of fines through the grate-slots. Such a machine is in operation at the Garfield plant of the American Smelting & Refining Co., Utah, treating per day about 35 tons of a fine copper sulphide concentrate, of which 45 per cent. will pass a 200-mesh screen. The sulphur in the raw charge amounts to about 30, and in the sintered product to about 6 per cent. Other machines of this type are in operation in other plants of this company, but machines of the straight-line type have been chosen for the more recent installations.

The following data may supplement the details given with the three types of machines that are in operation at present:

For a grate-surface of 30 sq. ft., treating a charge with about 15 per cent. of sulphur, from 3,000 to 4,000 cu. ft. of hot gases have to be handled per minute. The vacuum varies from 2 to 7 and averages 5 oz. The wheel of the fan which produces the suction has to be cast heavier than ordinarily in order to withstand the wear of fine particles that pass through the grates. The Salida fan has a wheel 32 in. in diameter, 10-in. face, 13-in. inlet and outlet, runs from 1,500 to 1,900 rev. per min., and consumes from 10 to 20 h-p. The temperature of the gases at the fan ranges from 100° to 150° C. The latest practice is to use large, slow-speed fans. Such a fan has an impeller wheel 66 in. in diameter, with a 7-in. face, and makes 660 rev. per min., and handles about 3,600 cu. ft. of gas at a temperature of 180° C., creating a vacuum of 4 oz. and consuming 19 i.h-p. This volume corresponds to a machine having a suction-box 30 by 150 in. Running the fan at 800 rev. per min. makes it answer for two machines.

In treating pyritic ore some sulphur is driven off and vapor deposited in the casing, whence it is removed at intervals through clearing-doors. The amount of fines which falls through the grate has been found to range from 3 to 5 per cent. of the weight of the charge; the bulk of this material is removed through doors in the suction-box.

In making up a charge, it is essential that the constituents be intimately mixed and uniformly moistened; the amount of water added varies with the character of the ore and ranges from 6 to 10 per cent.

As to the chemical composition, the charge-components

ought to be so apportioned as to furnish a slag that forms at a low temperature and requires little superheating to become fluid. The range of SiO_2 lies between 10 and 85 per cent.; it is better to have FeO in excess of CaO than *vice versa*; Pb can be high or low; charges with Pb , 60 per cent., are being run successfully; S , as low as 10, but a good average is 18 per cent., while with more than 20 per cent. the process is much retarded. However, in treating copper-ores with which the sulphur-content has to be reduced only to 8 or 10 per cent., the charge can contain as much as 25 per cent. of sulphur.

Field-Investigations of Structural Materials by the U. S. Geological Survey.

BY ERNEST F. BURCHARD, WASHINGTON, D. C.

(Pittsburg Meeting, March, 1910.)

IN connection with the work of testing structural materials for the use of the U. S. Government at the laboratories of the technologic branch of the U. S. Geological Survey at St. Louis, Mo., from September, 1904, to April, 1909, and since then at Pittsburg, Pa., large quantities of sand, gravel, and crushed stone have been needed from time to time, besides samples of building-stone, clays, and other quarry-products. In many instances it has been necessary to obtain single samples of sand, gravel, or crushed stone in lots of a car-load or more. For obvious reasons all these collections have had to be made by a representative of the Survey. As the work progressed it was found essential that numerous geologic data should be gathered regarding the materials collected, in order that they might be properly classified as to kind of material, source, geologic age, etc., and that they might be rated according to quantity available, accessibility to transportation facilities, approximate costs, suitability for special purposes, etc., and that notes might be taken regarding undeveloped deposits of possible value. Furthermore, it was desired that the selection of materials for tests should be made broadly, so as to cover, first, the representative types of material, and later, if possible, the typical materials of the more important building-centers in the United States.

In order to insure a certain degree of uniformity in this work and economy of effort and expense, it was decided that as much of the sampling as was practicable should be done by a member of the geologic branch, whose regular field-trips could be combined conveniently with those necessary for procuring materials for the laboratory. During parts of the last three years I have been engaged in field-work of this sort.

The results of the field- and laboratory-investigations of structural materials are intended primarily for the information of those departments of the government which are engaged in construction-work—namely, the office of the Supervising Architect of the Treasury Department; the War Department; the Isthmian Canal Commission; the Reclamation Service of the Interior Department; and the Navy Department. The field- and test-data have been made available to these departments, although comparatively little of the information has yet been published. However, when fairly complete information has been obtained that is thought to be of general interest, it has been compiled and published in bulletins by the Geological Survey.

Prior to the fiscal year 1909–1910 the making of general typical collections and of special areal studies was the principal work undertaken. In the spring of 1909 a request for information was received by the Director of the Survey, through the Secretary of the Interior, from the Secretary of the Treasury, accompanied by a list of about 380 cities in which the construction of new Federal buildings and extensions had been authorized by Congress and would be in progress in various stages within the next three or four years. This work will involve an expenditure of not less than \$50,000,000. The following quotations from this request are therefore of interest here:

“It will be in the interest of the Government to have the Geological Survey furnish this Department with information as to the character and extent of the sands, gravels, stone, and other materials suitable for work in concrete construction; sands for mortars; stone for masonry work; brick, terra cotta, hollow tile, and other structural materials that may be suitable and available for use in the construction of these buildings within easy reach of each of the localities named in this list. Exact and thorough data of this kind will not only be of great service in connection with the construction of the buildings in question, but also in the preliminary planning of them.”

“Reports should be submitted to the Supervising Architect’s office from time to time, as rapidly as any part of this work can be completed, or definite results obtained, without awaiting publication, in order that this information may be available for use in the planning and construction of public buildings already authorized.”

In view of the urgency of this request, it became necessary to make this work a special order of business, rather than an incident to other field-trips. Therefore, during the second half

of 1909 part of the time of six geologists, J. A. Holmes, T. Nelson Dale, N. H. Darton, J. E. Todd, James A. Gardner, and J. A. Udden, and all of my time was spent on this work, with the result that about 85 per cent. of the 380 specified localities, including all where the need was urgent, were visited and a field-report on each one was prepared and sent to the Supervising Architect. At the outset it was planned that there should be uniformity in the reports, and therefore they were prepared mostly according to the following outline, care being taken that only data of a practical character should be given :

Structural Materials Investigated for Use in Federal Buildings.

I. *Stone :*

- A. Dimension stone $\left\{ \begin{array}{l} a. \text{ Foundations.} \\ b. \text{ Walls.} \\ c. \text{ Sills and trim.} \end{array} \right.$ for exterior.
- B. Ornamental stone for interior (marble, serpentine, onyx, etc.).
- C. Slate for roofing, sanitary fixtures, etc.

II. *Material for concrete :*

- A. Sand.
- B. Gravel.
- C. Crushed stone, slag, cinder, shell, etc.
- D. Cement—Portland, natural, hydraulic, etc.

III. *Clay products :*

- A. Brick. $\left\{ \begin{array}{l} a. \text{ Common.} \\ b. \text{ Front (pressed, rough, fire-faced, etc.).} \end{array} \right.$
- B. Tile. $\left\{ \begin{array}{l} a. \text{ Roofing.} \\ b. \text{ Hollow building-tile or block.} \end{array} \right.$

IV. *Materials for mortars and plasters :*

- A. Lime. $\left\{ \begin{array}{l} a. \text{ Quick.} \\ b. \text{ Hydrated.} \end{array} \right.$
- B. Gypsum wall-plasters.
- C. Sand.

The work was necessarily done very rapidly, and the reports were not written for geologists, but rather for the use of persons who may not have had training in geology. The view-points of the geologist, however, respecting extent, quality, structure, and general geologic relations that affected the utilization of material were borne in mind throughout the work. The reports as type-written range in length from 1 to 12 pages but average less than 5 pages.

In making these field-studies it was the endeavor to relieve

the laboratory of all work possible and to give to the Supervising Architect a definite opinion as to the value of the material, backed up by a detailed description of it and the results of field-tests. In addition, any authentic test-data in possession of the producer or contained in State geological survey reports were utilized. The common points considered with regard to stone, gravel, clay, gypsum, etc., were noted on forms in loose-leaf books. Many special details with regard to the various materials had to be investigated, and for brick and other clay-products notes were kept regarding the processes of manufacture. Sands were subjected to qualitative tests for the presence of lime, alkali, clay, magnetite, quicksand, and silt. Granular-metric analyses were made and the material was critically examined under the field-lens. A knowledge of the Architect's general specifications was requisite, and as a rule the geologist was able to tell, after a careful investigation, whether a sand, gravel, stone, or brick would fulfill these specifications or not.

To the question as to what direct advantage these reports would be to the Supervising Architect, or to federal construction-work in general, the following answer may be given:

(a) Attention is called to materials of merit which owing to their proximity to the building site should be obtainable at lower prices than similar materials occurring long distances away.

(b) Attention is called to little-developed and hitherto comparatively unknown materials that may possess special merit for certain kinds of work.

(c) Warning is issued against the use of materials that are not suitable yet are commonly used in certain localities.

(d) Warning is issued against the acceptance of materials from deposits which may be of good quality, but of insufficient quantity.

(e) Warning is issued against the acceptance of materials from deposits which may afford small samples of material of excellent grade but whose quality as a whole is inferior.

(f) Data regarding local costs and freight-rates are obtained on small and large lots of all materials shipped into the locality, such as cement, stone, sand, wall-plasters, etc., thus affording aid towards the preparation of specifications for new buildings.

In addition to the results of this work as related to the gov-

ernment, its relation to the country at large may be mentioned. Where little-known but meritorious materials are thus brought to the attention of the Supervising Architect, and incidentally to that of the public, as they doubtless will be later through their use in federal buildings and their description in published reports, the utilization of important natural resources is encouraged. During the past field-season many materials that would probably otherwise have been passed unnoticed have been brought to the attention of the Supervising Architect.

Besides the work outlined above, there have been at times during the past year at the laboratories of the Survey, both in Pittsburg and in Washington, special investigations of such subjects as the manufacture of hydrated lime and studies of Keene cement and wall-plasters, tending towards the formulation of standard specifications for these materials in government construction-work. Here again the services of field geologists have been required to procure the samples and the geologic data of the Survey thereby enriched.

A Commercial Fuel-Briquette Plant.

Discussion of the paper of Mr. Blauvelt, presented at the Pittsburg Meeting,
March, 1910, and published in *Bulletin No. 39*,
March, 1910, pp. 223 to 235.

CHARLES T. MALCOLMSON, Chicago, Ill.:—Mr. Blauvelt's admirable paper is a valuable contribution to the literature on briquetting of coal in this country. It should have a special significance for those interested in the commercial development of the coal-briquette industry. I believe that the data included in Mr. Blauvelt's paper will be particularly useful because they represent costs taken from a briquette-plant in actual operation.

There are several points touched on in Mr. Blauvelt's paper which may bear comment in the way of emphasis rather than of criticism. In the first place, he has stated a fact which becomes axiomatic to any one who has had any experience in the design, building, or operation of coal-briquette plants, and that is, that the press is only one factor in the successful operation of such a plant. I have observed from my experience and from my knowledge of the troubles of other briquette-plants that practically all the failures can be attributed to a disregard of this fact. The successful plant is the one in which all of the elements making up the plant have been given due consideration. The preparation of the coal before briquetting is of more importance in an economic way than the press used in making the briquettes, except in so far as the type of press determines the size or shape of the briquettes made.

Coal-briquetting is a simple operation if viewed from the steps in the process. Coal and a suitable binder are mixed together, heated, and subjected to pressure. The exactness with which these relations are maintained determines the uniformity of the product, and has a vital bearing on the cost of making this product. In the first place, the coal must be dry, and the binder must be introduced into the coal with as little moisture as possible. Experience has shown that a certain percentage

of moisture is necessary to make good briquettes, but if the moisture-content exceeds 5 per cent. the product deteriorates in value. The percentage of moisture in the mixture varies with different coals; therefore, that part of the plant is designed to meet the requirements. The temperature of the mixture is also varied with different fuels. These items have a direct bearing on the cost, so that the temperature is kept as low as is compatible with good operation. Mr. Blauvelt states that about 200 lb. of steam per ton of briquettes is required for heating the mixture. At the plant of the Standard Briquette Fuel Co., at Kansas City, we are preparing to install a gas-meter recently designed by Professor Thomas for measuring the quantity of superheated steam used in this plant for this purpose. Unfortunately, at the present time, we have not secured this data, but from other data obtained I believe the figure given by Mr. Blauvelt is high for the Kansas City plant. The quantity of steam, however, will vary according to its temperature. Some operators in Europe disregard the use of superheated steam other than that necessary to insure perfectly dry steam at the mixer.

On the other hand, there are plants at which the coal is heated before the binder is introduced, and the temperature of the mixture is also increased by direct heat, together with the introduction of steam into the mixture. There are objections to this method in the practical operation of a plant on account of the fire-risk and the caking of the mixture on the inside of the heaters. In the Kansas City plant we use the vertical type of heater mentioned by Mr. Blauvelt, and believe it has some points in its favor. It insures a more or less compact mass, in which the maximum temperature of the heating-agent is applied near the point of discharge of the mass from the heater, while the mixture as it enters the heater at the top receives the excess or uncondensed steam at atmospheric pressure after it has given up its superheat. It also allows the introduction of the steam into the mass under pressure, which increases the total heat in the steam.

The most important problem which we have yet to solve in connection with commercial briquette-plants is the binder. This is by far the largest single item of cost in the briquetting of coal, and the success or the failure of a plant may de-

pend, first, upon the cost of binder, and second, upon its uniform quality. In Europe the briquetting of coal has been developed through many years along with other means of utilizing fine or waste coal. This is notably true of the by-product coke-ovens. There the briquette industry consumes a large portion of the tar recovered in these ovens. As the consumption of this tar represents an important item in the commercial success of this form of coke-ovens, and the briquette industry consumes the major portion of the tar so produced, the requirements for briquetting-pitch have been met by the producers of by-product coke. The two industries must of necessity work hand in hand. I cite the coke-oven industry because this is the largest producer of tar, the pitch of which is used mainly for briquetting purposes.

In the United States the tar, whether it be recovered from by-product coke-ovens, from the manufacture of illuminating-gas by destructive distillation of coal, or from tar recovered in the washing of water-gas enriched with petroleum, has found markets in other channels, notably in the roofing and paving industries. These industries have not required the exactness in the manufacture of pitch which is essential to the making of good briquettes. For instance, it is a common practice in the United States to "cut back" a still of pitch if the distillation has been carried beyond the proper point to produce pitch of a given melting-point, or hardness. This means that oils are introduced into the still to soften the pitch after the fires are drawn.

We have learned by experience a fact which has been known in Europe for some time—that there are certain oils in coal-tar which must be removed before the pitch can be used for the manufacture of briquettes, particularly for domestic purposes. If these oils are retained in the pitch, they volatilize at a temperature below that at which the coal burns, and in consequence smoke forms, which is not only objectionable on account of the odor, but the oils contained in it often condense in the cooler chimney, collecting the finely-divided carbon of the smoke and obstructing the draft. When briquettes made with pitch of this character are used on locomotives, the dust and fumes from the briquettes irritate the face and eyes of the firemen.

In order to develop the industry to a point where the proper briquetting-pitch can be specified and maintained at all times, considerable investigation will be necessary, the cost of which must be reckoned in the cost of the finished product. At the present time the low selling-price of fuels in the United States leaves small margin for an excessive cost of binder, since briquettes must be made at a figure between the selling-prices of the slack- and lump-coal and leave a margin of profit.

These problems have yet to be worked out commercially; but there is much encouragement from the attitude of the large tar-distillers in the United States, who have given every evidence of their willingness to bear their share of the burden.

There is a point only touched on by Mr. Blauvelt in his paper, regarding the advantage in the use of hard or dry pitch, as compared with a softer pitch introduced into the mixture in liquid form. Experience has shown that a pitch of higher melting-point does not work so well with the liquid process. A proposition, however, of larger economic value for the future is found in using a hard pitch which can be shipped in bulk in all seasons and which will give the tar-distiller the more valuable oils resulting from the manufacture of such pitch. In Europe the practice is quite general of distilling the pitch beyond a point at which it can be used even for briquetting purposes in order to obtain the valuable anthracene oils. This hard pitch is "revivified" by the admixture of a softer pitch. The hard pitch is always shipped in bulk; the softer pitch must be handled in barrels, which adds to its cost. In the United States the manufacture of aniline dyes, alizarine, and other chemicals obtained from the anthracene, has never become an important factor. Most of these chemicals are imported from Europe.

The development of this industry will undoubtedly follow the introduction of practical methods for the effective conservation of our fuel-resources, in which briquetting will play an important part.

JOHN BIRKINBINE, Philadelphia, Pa.:—Mr. Blauvelt's general reference to the numerous forms of briquette-apparatus brought to public notice in this country, as recorded in our *Transactions* and other technical publications, might have been

elaborated and made exceedingly instructive by detailed mention of the different forms and the business enterprises connected with their introduction, and a classification of them into those which were mechanically defective; those which were mechanically successful, but not economical; and those which were simply premature, because of the lack of public appreciation of their importance as methods of utilizing waste material.

With regard to the history of this question, as exhibited in our *Transactions*, I may supplement Mr. Blauvelt's statement by calling attention to the fact that, at the Philadelphia meeting of the Institute, in February, 1872, the late E. F. Loiseau presented orally a paper on the utilization of coal-dust,¹ which, however, was not published, Mr. Loiseau preferring to present later and more complete accounts² of his briquetting-method and his plant at Port Richmond, near Philadelphia. Meanwhile, in connection with the Hazleton meeting of October, 1874, the members of the Institute visited, near Mauch Chunk, the experimental works of Mr. Loiseau, who afterwards erected the larger plant at Port Richmond.

In addition to these accounts of Loiseau's process and machinery, our *Transactions* contain, besides references to the briquetting of ores, etc., an elaborate paper by Robert Schorr, of San Francisco, Cal.,³ on Fuel- and Mineral-Briquetting, the value of which is enhanced by a comprehensive bibliography, prepared by the author, and complemented with important additions by Professor Hofman.

But, apart from the foregoing suggestions for the assistance of those who would study the literature of this subject, I wish to recognize the significance of the data presented by Mr. Blauvelt, as constituting a welcome contribution to "the conservation of natural resources," by proposing a method of producing cheaply a satisfactory fuel from what is, in many localities, a refuse material; and I desire also to point out a special field in which such a method may be greatly useful.

¹ *Trans.*, i., 18 (1871-73).

² On the Manufacture of Artificial Fuel at Port Richmond, Philadelphia meeting, February, 1878, *Trans.*, vi., 214 (1877-78), and The Successful Manufacture of Pressed Fuel at Port Richmond, New York meeting, February, 1880, *Trans.*, viii., 314 (1879-80).

³ *Trans.*, xxv., 82 (1895).

The anthracite coal-fields of Pennsylvania have long been looked upon as offering inducements for some method of utilizing the fine coal. In late years many washeries have been installed to recover small sizes of anthracite from mine-waste, and numerous old culm-banks have been worked over for this purpose. But these washeries do not reach great quantities of coal which have been washed down the streams of the coal-region into the large creeks and rivers; and, in these, a considerable industry is carried on by flat-boats equipped with dredges and screens, which recover large amounts of fuel from stream-beds. The dredges win good coal from "pea"-size up, and the washeries save what is marketed as "rice"-coal (names indicating the approximate sizes); but the coal-dust is not recovered in either case, and the operation of the machines largely augments the amount of this which enters the streams.

The Water Supply Commission of Pennsylvania has received protests against the discharge into the streams of this fine anthracite and slate; and, as a member of that Commission, I welcome any practical suggestion for utilizing material which is obstructing stream-beds, doing great injury to cultivated lands, and polluting public water-supplies. This fine coal is admirably suited for the manufacture of briquettes, because the coal grinds to a powder more easily than the slate, and the difference in specific gravity permits a fair separation by simple sedimentation. At present, the "sludge" leaving the washeries is carried down the streams where the velocity is sufficient to transport it, but settles in quiet pools, obstructs the stream-flow, and changes the course of the channels. Freshets, lifting the mass, carry it forward and deposit it on cultivated fields, effectually killing their fertility. With each succeeding freshet the obstructed stream-channels force the freshet-waters, laden with coal-dust, over new areas of bottom-land, and, like a moraine, this wave advances down-stream to ruin new territory.

The conditions described in the anthracite-region are to a greater or less extent repeated in the bituminous-coal districts of Pennsylvania, and the condition of many streams of the State is deplorable. Our Commission faces the problem of reducing the permanent injury to some of the best bottom-lands, the obstruction of streams, and the pollution of water-

supplies, without working unnecessary hardship to the magnificent coal industry of the State. If the fine coal can be removed from the sludge and cheaply formed into briquettes, this measure may be a great public service. Perfect separation of finely-divided coal from slate-dust may not be necessary, for while the percentage of ash-producing material will influence the calorific and commercial values of briquettes, they may contain a considerable proportion of the slate and yet be a desirable fuel. The problem is not easy. There are difficulties in collecting the fine coal, and the expense of briquetting must be considered; but the field suggested above is worthy of investigation by those interested in briquetting, since the raw material is now not only a waste, but also a nuisance, and a serious menace.

R. W. RAYMOND, New York, N. Y.:—Speaking from my general recollection of the enterprise of Mr. Loiseau, to which Mr. Birkinbine has referred, and without pretending to know its commercial history, down to the death of the inventor in 1886, I may say that the opinion which I formed of it at the time would fairly place it among those otherwise excellent methods which Mr. Birkinbine characterizes as prematurely proposed. There was no question as to the quality of the product; but the process required one condition, upon which many other, and less meritorious, schemes of the kind were wrecked—namely, it called for pure material. Innumerable philanthropic and visionary reformers had gazed upon the big, black “culm-heaps” of the anthracite-region, estimated them as measuring the “waste of coal,” and dreamed of ways in which they could be “utilized.” And their various schemes were usually based upon the notion that these black piles of waste would furnish a raw material available for use at once, without other expense than that of handling it. In fact, probably none of these old dumps contained enough coal to be used, without previous concentration, in the form of briquettes or in any other form; the oldest of them, accumulated when small sizes of coal were not marketable, would pay for re-washing; and the great majority, accumulated after the introduction of the use of the smaller, smaller and smallest sizes of coal, were practically too poor in carbon to be economically handled at

all. Reformers and inventors alike seem to have regarded every dump of black slate as so much waste of coal.

Two men, more than any others, introduced effective remedies for the waste of coal in this way—namely, Franklin B. Gowen, who, as President of the Philadelphia & Reading Railroad Co., put upon the road of that company locomotives provided with special fire-boxes and grates for the burning of unsalable slack-coal; and Eckley B. Coxe, who was a leader in promoting the use of smaller sizes of coal. Mr. Gowen's innovation had but a moderate success. It is my impression that the Reading Railroad Co. is not now building locomotives of his type; and I am inclined to think that the economy which he sought to secure is now attained in other ways, less inconvenient to railway-service—among which, I fancy, Mr. Coxe's more profound and permanent improvements play an important part.

According to my recollection, Mr. Loiseau was subject to no delusions regarding the culm-heaps as a source of his raw material. He knew very well that he must have practically pure coal for his briquettes; and it was for this reason that he put his plant at Port Richmond, where the screenage, before further shipment, of coal received from the mines would furnish the quality of coal-dust which he required. In this view he was clearly right; for this secondary screening of coal, already more or less freed from slate in the breaker, certainly gives a waste product immensely richer in carbon than any old culm-heap in the country. There is one other way of obtaining such a product—namely, from the yards of the retail coal-dealers, who, receiving their anthracite by the boat-load, are obliged to screen it once more before delivering it to their customers. And this last screening probably furnishes the purest coal-dust of all. Unfortunately, the amount of such dust accumulated in a single dealer's yard is not likely to be great enough to warrant the erection of a briquette-plant for its utilization; and the cost of handling it and shipping it to a briquette-plant at some other point would be, very likely, enough to prohibit such a disposition of it. In spite of much loose denunciation of the "grasping coal-barons" of the anthracite-region, I venture to say that the price at which anthracite is sold on railroad-cars at the mine, and the price at which it is hauled

to tide-water, are astonishingly low, especially when compared with the cost of every subsequent handling of it; and that the utilization of any coal-dust, however pure, which involves its re-handling and re-transportation, at least in a city, makes it, not a raw material, available without cost as "waste," but a material more expensive than coal from the mine.

Without pursuing this argument further, I wish to say that Mr. Blauvelt's paper evidently describes the use of a relatively pure material. It presents no scheme for the preparation of black slate as a fuel. And Mr. Birkinbine's suggestion has in its favor the strong feature, that it indicates, as a source of supply, stream-deposits of a naturally concentrated, and therefore presumably pure, raw material. But an engineer, in considering this suggestion, is impelled to inquire whether any such stream-deposit in Pennsylvania is large enough to warrant the erection of a briquette-plant on the spot, or the establishment of mechanical means for its exploitation and a railroad for its transportation. If this is not the case, then it is more than doubtful whether the material, even if offered free of royalty by the owner of the land, could be dug up, carried away, and delivered to a briquette-plant, at a cost permitting competition with coal from the mine.

EDWARD W. PARKER, Washington, D. C. (communication to the Secretary *):—It may be of interest in connection with Mr. Blauvelt's paper to refer somewhat to the antiquity of the briquette industry. It is being considered as a comparatively new industry, whereas it is really more than 300 years old. I have recently seen a pamphlet printed in Great Britain in 1603, advertising "coal balls" for domestic use. The inventor had in mind two benefits to be secured: one was the utilization of the fine coal otherwise wasted, and the other was the provision of an occupation for persons who had lost their legs or were otherwise incapacitated for performing ordinary labor. The "coal balls" were cemented with tar and molded by hand. The pamphlet describing this invention and the claims of the inventor is in the possession of Prof. J. A. Holmes, of the Technological Branch of the U. S. Geological Survey.

* Received Mar. 11, 1910.

As is now well known, the history of briquette-making in the United States up to within quite recent years is one of many failures, and it is probable that the amount invested at the present time in practical briquetting-operations does not represent 10 per cent. of the amount invested in hopeless enterprises. The reason for these numerous failures, as I have already stated in a paper presented to the Institute,⁴ has been the attempted exploitation of patented and secret binders and processes. To these should be added the ignorance of the mechanical problems which had to be overcome in the development of methods capable of producing a fuel which was not only useful, but which would compete with the plentiful and cheap raw fuel. Fortunately, it has now become generally well recognized that the binder or cementing material to be used is one in which coal-tar forms the principal ingredient and which must be cheap. To my mind, one of the most important and encouraging incidents in connection with the development of the fuel-briquette industry in the United States is the establishment by the well-known engineering firm, Roberts & Schaefer Co., Chicago, of a separate branch devoted to the construction of briquette-plants, of which C. T. Malcolmson is now in charge. This specialization means that it is not now necessary for parties contemplating the building of a briquette-plant to go ahead blindly in the construction of the plant, which might result in installing mechanical arrangements which are ill-fitted to the work to be performed.

I am looking forward hopefully to the important part that the briquette industry will play in that interesting drama—the conservation of our natural resources.

⁴ *Trans.*, xxxviii., 582 (1908).

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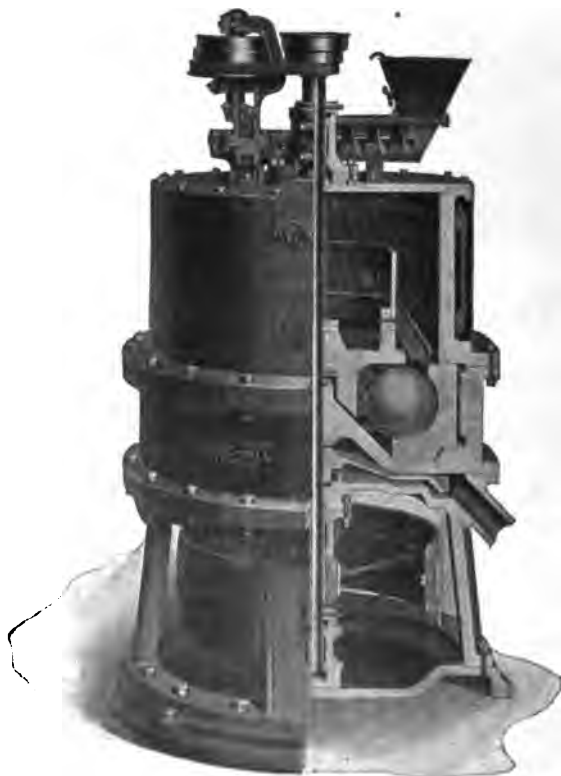
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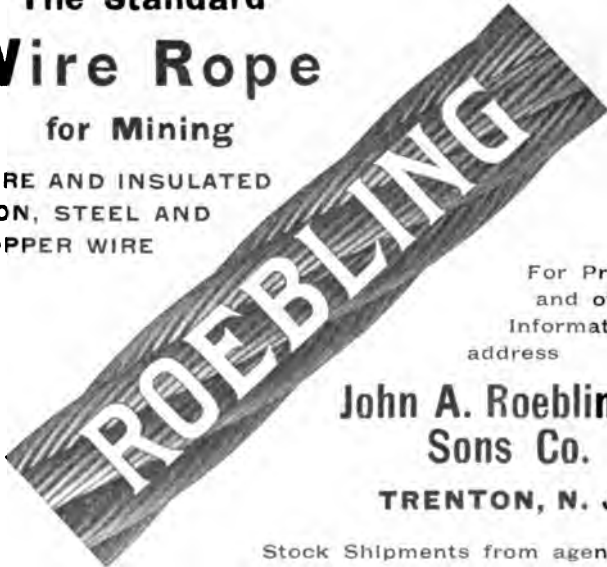
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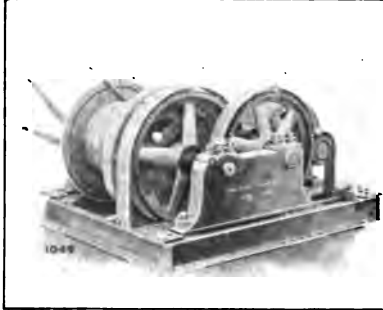
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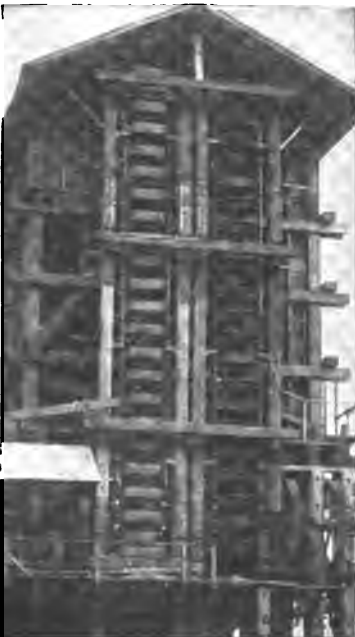
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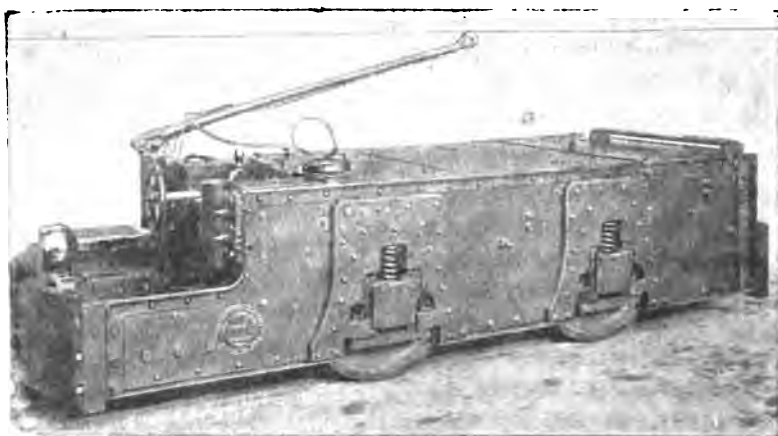
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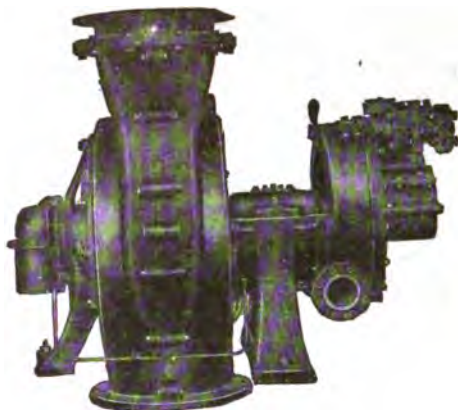
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